CALIFORNIA FISH AND GAME

"CONSERVATION OF WILDLIFE THROUGH EDUCATION"

VOLUME 56 JULY 1970 NUMBER 3

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CONTENTS

CHANGE OF EDITORSHIP

With this issue, Carol M. Ferrel of the Wildlife Management Branch assumes the duties of Editor-in-Chief of *California Fish and Game.*

Mr. Ferrel's assumption of the editorship follows the department's policy of rotating the editorship of its quarterly technical journal between staff members representing Wildlife Management, Inland Fisheries, and Marine Fisheries.

Mr. Ferrel, whose position is Wildlife Management Supervisor, has served as Editor for Wildlife with the publication for many years and from 1958–62 was Editor-in-Chief.

Under his guidance, the journal will continue its policy of presenting to the public the results of scientific investigations as they relate to management programs and the conservation of California fish and wildlife resources.

Mr. Ferrel will be ably assisted in his duties by five associate editors: Stephen J. Nicola, Inland Fisheries; Merton N. Rosen, Wildlife Management; Herbert W. Frey, Marine Resources; and Donald H. Fry, Jr. and Harold K. Chadwick, Anadromous Fisheries.

To Mr. Shapovalov, Editor-in-Chief the past 4 years, we wish to express our appreciation for a job well done.—*G. Ray Arnett, Director California Department of Fish and Game.*

Calif. Fish and Game, 56 (3) : 145–155, 1970

SOME ECOLOGICAL EFFECTS OF DISCHARGED WASTES ON MARINE LIFE[1]

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and
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Scripps Institution of Oceanography
San Diego, California

The number of macroscopic species present at five stations ranging in depths from 45 to 65 ft off the Palos Verdes Peninsula, near San Pedro, California, was negatively correlated to the amount of fine grain organic-laden sand present in the sediment. Organic rich sediments were thickest at stations near the outfall. Accumulation of this material at these depths appears to have modified or covered substrates otherwise suitable for the settlement of many epibenthic species.

INTRODUCTION

Every day approximately one billion gallons of sewage are discharged into the shallow nearshore marine environment in southern California. Despite the volume of this effluent, little is known about its ecological effects (Turner, Ebert, and Given, 1966, 1968; California State Water Quality Control Board, 1965; North, 1963).

The largest sewerage system in southern California in terms of discharge is the Los Angeles sewer outfall at White Point, Palos Verdes Peninsula (near San Pedro, California) where approximately 360 million gallons are discharged daily. The depth of the outfall terminus and diffusers ranges between 165 and 195 ft. Treatment is primary. The Los Angeles County Sanitation District began discharging sewage effluent at White Point in 1934 at a rate of 17 m.g.d. A gradual increase in this rate has continued until the present time. Design capacity is 450 m.g.d.

In 1954, the Institute of Marine Resources (I.M.R.) of the University of California contracted to study the effects of oceanic disposal on the nearshore environment at White Point. This study included a survey of the effect of effluent on the biology of the area. The present paper describes the results of a recent survey (June, 1969) that partially duplicated this program. The purpose was to collect comparable data, and to examine these in order to detect possible long term ecological changes.

METHODS

Detectable changes in the epibenthic communities living on rocky substrates around the outfall were estimated by Conrad Limbaugh (unpublished I.M.R. report) to cover a distance of ¾ to 2 miles of coastline in 1954. To determine whether the effect of the outfall has either changed or spread, five diving stations were selected at locations

[1] Accepted for publication March 1970.
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from 1.5 miles south to 6.5 miles north of the outfall (Figure 1). More southerly stations were not selected because of an inappropriate substrate and the proximity to Los Angeles Harbor at San Pedro. At each station quantitative counts (numbers per m^2) of macroscopic (visible

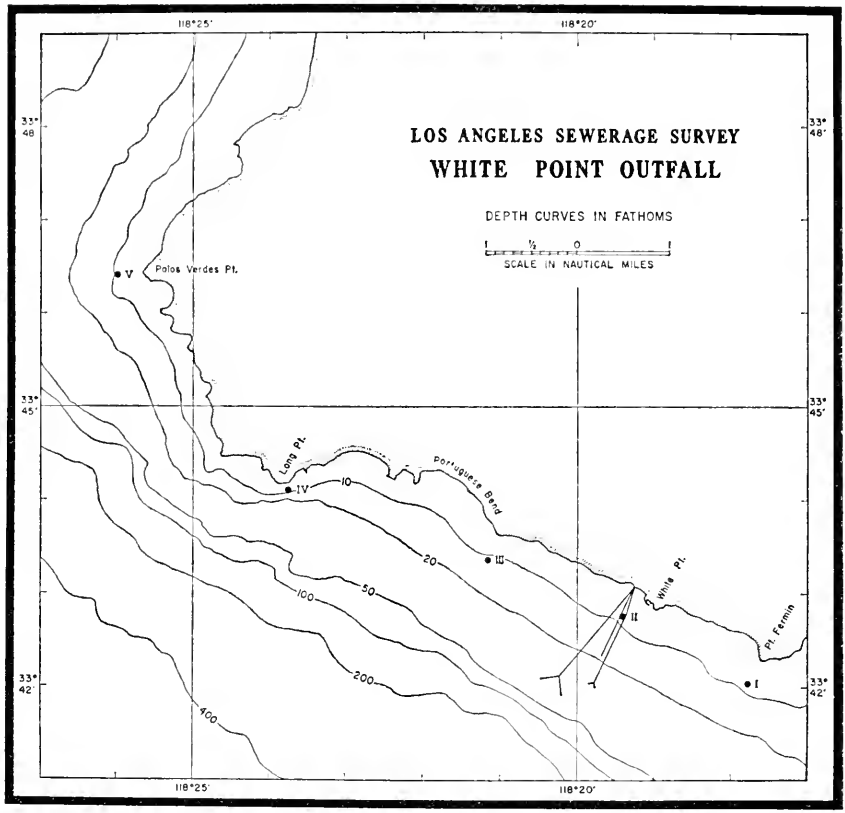

FIGURE 1. Location of stations on the Polos Verdes Peninsula near San Pedro, California.

to scuba divers) epibenthos were made at previously marked random points along a 50 m transect line placed on the bottom. This method gives estimates of abundance as well as information about distributional pattern (Grigg, ms.). Qualitative estimates of the abundances of common organisms over much larger areas, collections, sediment cores, and photographs also were obtained at each station. In the laboratory cores were shaken and allowed to settle. The thickness of a layer of very fine sand (~0.1 mm) laden with organic matter was measured in each sample (Figure 2, Table 1). Organic matter was adsorbed to the surfaces of most sand grains of this size.

RESULTS

The thickest layers of organic laden sediment were found at stations near the outfall (Table 1). In 1954, in an area covering 0.2 square miles around the outfall, D. L. Inman and E. D. Goldberg (unpub-

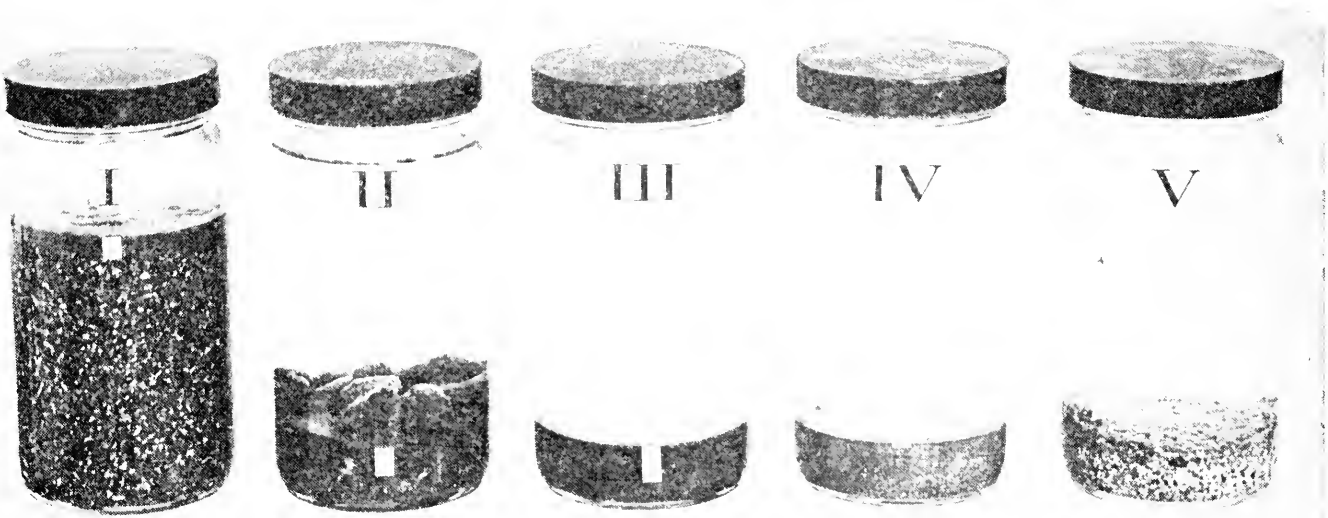

FIGURE 2. Sediment cores collected at Stations I–V. The amount of fine grain organic laden sediment present in each core is indicated by the white bar.

TABLE 1

Station Descriptions, Number of Species, and Amount of Organic Laden Sediment

Station	Depth (feet)	Distance from outfall (miles)	Area covered (m^2)	Algal growth	Thickness of fine grain organic laden sediment (cm)	Number species	Species of fish	Notes
I	50	1.5 south	5,000	None	0.80	37	8	Few living organisms observed under rocks
II	50	(On pipeline)	4,000	None	0.90	38	5	*Pododesmus* very abundant on pipe
III	65	1.5 north	4,000	None	1.20	24	3	Onuphid worms very abundant
IV	45	4.0 north	4,000	Sparse	0.15	39	8	Dense spawning aggregations of *Kelletia* present
V	50	6.5 north	5,000	Sparse	0.10	65	28	Past history of productive lobster fishing

lished I.M.R. report) found concentrations of organic matter in the surface sediment (upper 5 cm) at least three times greater than normal. In the present study, the highest concentration was observed at Station III, where the smallest number of species (24) was counted. At Station V, where organic laden sediments were least apparent, the greatest number of species was observed (65). Of these, three were algae; compared to seven reported by Strachen and Koski (1969) at the same station at 60 ft in March of 1966. The commercially important species; abalone, spiny lobster, and giant kelp were not observed at Station V. No fish suffering from aberrations as described by Young (1964) were seen at any station.

Six species, the tube anemone, *Pachycerianthus* sp.; Kellet's whelk, *Kelletia kelleti*; the short-spined starfish, *Pisaster brevispinus*; the common rock crab, *Cancer antennarius*; the bat starfish, *Patiria miniata*; and the yellow-green sea slug, *Hermissenda crassicornis* were relatively more abundant at those stations containing high amounts of organic rich sediment (Tables 2 and 3). Conversely, species that were absent or relatively rare at stations where organic laden sediments were thickest, were more common in areas where sediments were thinnest. These included the algae, *Dictyopteris* sp. and *Rhodymenia* sp., the invertebrates, the southern California cucumber, *Parastichopus californicus*; the red sea urchin, *Strongylocentrotus franciscanus*; the purple sea urchin, *S. purpuratus*; the purple starfish, *Pisaster ochraceus*; and the giant keyhole limpet, *Megathura crenulata*.

DISCUSSION AND CONCLUSIONS

Underwater observations of sublittoral rocky bottom communities in the vicinity of the Los Angeles Sewer Outfall at White Point indicate that large scale ecological changes have occurred in this area. In June 1969, many economically important species that normally occur over rocky substrates at depths from 45 to 65 ft, such as the kelp, *Macrocystis pyrifera*, spiny lobster, abalone, and many species of fish were either rare or absent (Table 2). A survey of this area in 1954 by Limbaugh (unpublished I.M.R. report) indicated that similar effects from the outfall were detectable along $\frac{3}{4}$ to 2 miles of coastline. The length of coastline affected in 1969 was about 6 miles, at least three times greater than in 1954.

Certain similarities between the 1954 and 1969 survey are apparent (Table 4). In both, seaweeds normally abundant on solid substrates between 45 and 65 ft were almost absent. Species directly or indirectly dependent on marine algae as a basic food source were limited in number. In 1956, the black abalone, *Haliotis cracherodii*, taken at White Point, were stunted and the meat was flaccid (Young, 1964). Since little plant material was present, reduced growth of the abalone was primarily attributed to starvation. The most abundant species at White Point in 1969 appear to be those capable of utilizing particulate organic matter (Figure 3).

The almost complete absence of algae at depths from 45 to 65 ft appears to be due to deposits on the bottom which have modified or covered an otherwise suitable substrate. At depths less than 30 ft, however, wave activity may keep fine grained material in suspension. At

TABLE 2

Absence, Presence, and Subjective Estimates of Abundances of Macroscopic Species Observed at Stations I-V

Species	Common name	Presence					Abundance				
		I	II	III	IV	V	I	II	III	IV	V
Algae											
Dictyopteris sp.	Brown algae				x	x					
Macrocystis pyrifera	Giant kelp										
Rhodymenia sp.	Red algae				x	x					
Corallina sp.	Coralline algae				x	x					
Coelenterates											
Paracyathus sp.	Solitary coral					x					
Telia crassicornia	Red anemone	x					rare(1)				
Telia lofotensis	Beaded anemone		x					rare(1)			
Corynactis californica	Colonial anemone	x	x	x	x	x	ab.		ab.	ab.	
Pachycerianthus sp.	Tube anemone	x	x	x	x	x	ab.	ab.	ab.	ab.	mod.
Muricea californica	California rust gorgonian	x	x	x	x	x					
Muricea fruticosa	California bushy gorgonian	x	x	x	x	x					
Lophogorgia chilensis	Pink gorgonian	x	x	x	x	x					
Miscellaneous worms											
Sabellid worms	Feather-duster worms					x					
Serpulid worms	Serpulid worms	x	x			x					
Chaetopterus sp.	Parchment tube worm	x	x	x							
Onuphid worms	Bamboo worms			x					ab.		
Dendrostoma sp.	Peanut worm				x	x					
Molluses											
Haliotis assimilis	Threaded abalone		x			shell					
Haliotis rufescens	Red abalone					shell					
Astraea undosa	Wavy top shell				shell						
Kelletia kelleti	Kellet's whelk	x	x	x	x	x	ab.	ab.	ab.	ab.	few
Neosimnia sp.	Canoe shell	x			x						
Calliostoma sp.	Top shell	x			x						
Hinnites multirugosus	Rock scallop	x	x		x	x					ab.(50)
Pododesmus cepio	Rock jingle	x	x	x		x		ab.			
Cypraea spadicea	Nut brown cowry	x	x	x	x	x		ab.	mod.	ab.	
Megathura crenulata	Giant keyhole limpet					x					ab.
Anomea peruviana	Southern jingle	x	x	x		x					

Crepidula onyx	Onyx slipper shell		x			x					
Hermissenda crassicornis	Yellow green sea slug	x	x	x	x		ab.	ab.	ab.	ab.	
Dorids	Nudibranch	x	x		x	x					
Cadlina sp.	Pale yellow nudibranch	x	x								
Duvaucelia festiva	Nudibranch	x	x	x							
Flabellinopsis iodinea	Purple sea slug	x	x	x	x						
Pholadids	Boring piddock	x	x	x	x	x	ab.	ab.	ab.	mod.	rare
Arthropods											
Cancer antennarius	Common rock crab	x	x	x	x		ab.	ab.	ab.	rare	
Cancer anthonyi	Yellow crab	x	x	x	x						
Paguristes sp.	Hermit crab	x	x		x	x					
Amphipods	Amphipods					x					
Spirontocaris sp.	Broken back shrimp		x		x	x					
Hippolytes	Shrimp					x					
Opisthopus transversus	Pea crab					x					
Lophopanopeus diegensis	Crab		x								
Pyromia tuberculata	Crab		x								
Scyra acutifrons	Masking crab										
Bryozoa											
Bugula sp.	Bryozoan	x	x	x	x	x					
Echinoderms											
Strongylocentrotus franciscanus	Red sea urchin	x	x		x	x	rare				
Strongylocentrotus purpuratus	Purple sea urchin		x		x	x	----------	rare	----------	rare	
Pisaster ochraceus	Purple starfish				x	x					
Pisaster brevispinus	Short-spined starfish	x	x	x			ab.	ab.	ab.		
Pisaster giganteus	Giant starfish	x	x	x	x	x					
Patiria miniata	Bat starfish	x	x	x	x	x	ab.	ab.	ab.	ab.	rare
Henricia sp.	Red starfish					x					
Pycnopodia sp.	Sun starfish										
Ophioplocus sp.	Brittle star				x	x					
Ophiopteris sp.	Brittle star				x	x					
Parastichopus californicus	Southern California cucumber				x	x					
Cucumaria sp.	Sea cucumber					x					
Tunicates											
Tunicate	----------					x					
Fish											
Paralabrax clathratus	Kelp bass					x	----------	----------	----------	----------	rare(5)
Paralabrax nebulifer	Sand bass	x			x	x	----------	----------	----------	----------	rare(10)
Sebastes serriceps	Treefish					x					
Sebastes serranoides	Olive rockfish	x	x	x	x	x					
Sebastes mystinus	Blue rockfish	x	x	x	x	x					
Sebastes auriculatus	Brown rockfish	x	x			x					
Scorpaena guttata	California Scorpionfish	x	x		x	x	rare	rare	----------	----------	rare(10)

TABLE 2—Continued

Absence, Presence, and Subjective Estimates of Abundances of Macroscopic Species Observed at Stations I-V

Species	Common name	Presence					Abundance				
		I	II	III	IV	V	I	II	III	IV	V
Fish—Continued											
Trachurus symetricus	Jack mackerel					x					1 school
Atherinids	Silversides					x					(50)
Torpedo californica	Pacific electric ray			x							
Coryphopterus nicholsi	Bluespot goby	x	x		x	x					ab.(50)
Artedius sp.	Sculpin					x					rare
Lythripnus dalli	Bluebanded goby					x					
Lythripnus zebra	Zebra goby					x					
Amphysticus argenteus	Barred surfperch	x				x					
Rhacochilus toxotes	Rubberlip surfperch					x					mod.(15)
Rhacochilus vacca	Pile perch					x					
Embiotoca jacksoni	Black perch	x				x					mod.(15)
Anisotremus davidsoni	Sargo					x					
Pleuronichtys coenosus	C-O Sole				x	x					
Halichoeres semicinctus	Rock wrasse					x					rare(4)
Oxylebius pictus	Painted greenling				x	x					
Girella nigricans	Opaleye					x					ab.(50)
Chromis punctipinnis	Blacksmith					x					ab.(50)
Oxyjulis californica	Senorita				x	x					ab.(200)
Pimelometopon pulchrum	California sheephead					x					rare(1)
Medialuna californiensis	Halfmoon					x					mod(15)
Hypsypops rubicunda	Garibaldi					x					mod(30)
Total number species		37	38	24	39	65					

x = Present.
Abundant = over 50 individuals observed during a dive.
Moderate = 10-50 individuals observed during a dive.
Rare = less than 10 individuals observed during a dive.
In some cases estimated numbers are in parenthesis.

TABLE 3

Abundance of Species (Numbers/m²) *

Species	Transect I†	Transect II	Transect III	Transect IV	Transect V
Dictyopteris sp.	----	----	----	0.30	0.60
Corallina sp.	----	----	----	0.10	----
Muricea californica	.55	2.20	0.80	0.60	0.40
Muricea fruticosa	----	.10	----	----	0.10
Lophogorgia chilensis	.25	.10	1.80	----	----
Pachycerianthus sp.	.25	.60	1.30	1.50	----
Corynactis californica‡	35%	40%	----	40%	----
Megathura crenulata	----	----	----	----	0.60
Cypraea spadicea	----	----	----	0.40	----
Kelletia kelleti	.05	.50	0.10	2.60	.20
Neosimnia sp.	.05	----	----	----	----
Astraea undosa	.05	----	----	----	----
Pholads	.25	----	----	----	----
Hermissenda crassicornis	----	.10	0.30	0.80	----
Parastichopus californicus	----	----	----	----	0.80
Cancer antennarius	----	.10	0.10	----	----
Patira miniata	----	.40	0.70	1.80	----
Pisaster brevispinus	----	.20	----	----	----
Pisaster ochraceus	----	----	----	0.20	1.70
Strongylocentrotus franciscanus	----	.10	----	0.80	3.60
Strongylocentrotus purpuratus	----	----	----	----	0.60
Scorpaena guttata	----	.10	----	----	----

* All transects covered 10 m², except Transect I, which covered 20 m².
† Transect Numbers Correspond to Station Numbers.
‡ Density given by % cover.

TABLE 4

Comparisons of Species Abundance at White Point in 1954 and 1969

Species more abundant than expected in 1954 and 1969	Species more abundant than expected in 1954 only	Species more abundant than expected in 1969 only	Species less abundant than expected in 1954 and 1969
Pisaster brevispinus	*Strongylocentrotus franciscanus*	*Cancer antennarius*	*Egregia laevigata*
Patiria miniata	*Strongylocentrotus purpuratus*	*Cancer anthonyi*	*Eisenia* sp.
Pachycerianthus	*Haliotis assimilis*	*Kelletia kelleti*	*Pelvetia* sp.
	Pycnopodia helianthoides	*Hermissenda crassicornis*	*Macrocystis pyrifera*
	Pisaster giganteus	*Sebastes serranoides*	*Haliotis corrugata*
	Sebastes paucispinis	*Sebastes mystinus*	*Haliotis fulgens*
			Haliotis rufescens
			Astraea undosa
			Panulirus interruptus
			Rhacochilus vacca
			Rhacochilus toxotes
			Girella nigricans
			Paralabrax clathratus
			Pimelometopon pulchrum
			Embiotoca jacksoni
			Halichoeres semicintus
			Oxylebius pictus
			Heterostichus rostratus
			Hypsypops rubicunda
			Oxyjulis californica
			Scorpaena guttata
			Coryphopterus nicholsi

these depths. North (1963) did not find substantial accumulation of fine sediments at White Point and attributed the absence of giant kelp there to benthic grazing by the red and purple sea urchins. At greater depths in 1969, we found these urchins to be either rare or absent at Stations I–IV (Table 2), and abundant only at Station V (Table 3). At Station II, most individuals were characterized by stunted and thickened primary spines. Many appeared moribund. It is not likely, therefore, that the absence of algae near the outfall at these depths in 1969 can be attributed to the grazing activities of urchins.

Data collected during the 1969 survey show that the number of species enumerated at each station is negatively correlated with the amount of fine grain organic laden sediment present in the cores (Kendall Tau Correlation Coefficient, -0.80, $p. = 0.10$). Fish appear to be particularly affected (Table 1). The reduction of benthic species is probably due to decreased settlement and survival of their larvae caused by fine grained sediments which cover the bottom. Since these benthic species make up the diet of many resident fishes, numbers of resident fishes in turn would be expected to decline. In an 8-year study of southern California kelp bed resources, it was found that the diversity (number of species) of fish was not altered significantly by the presence or absence of giant kelp but rather was positively correlated with the degree of bottom relief (North and Hubbs, 1968). Since the bottom topography at White Point has not changed, the decline of fishes there,

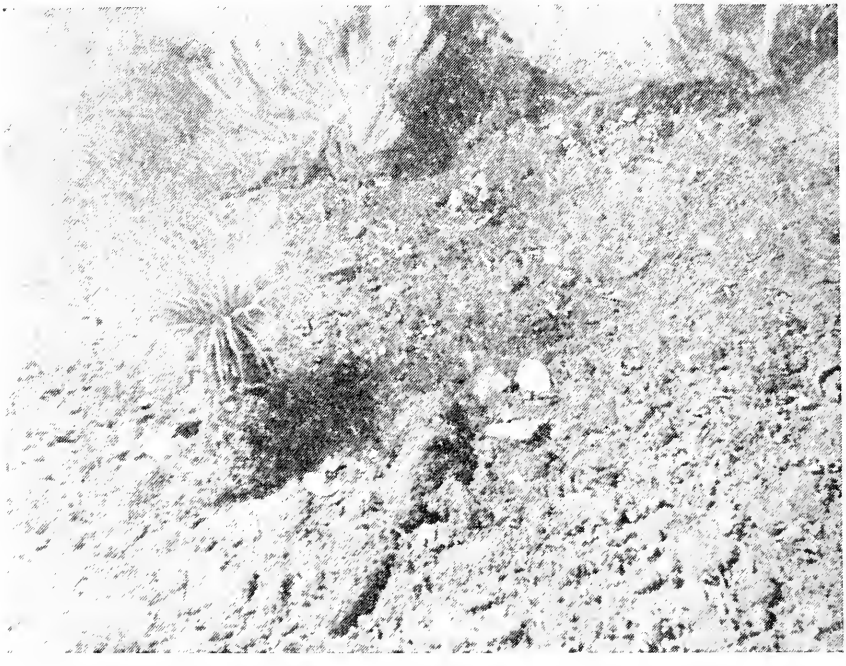

FIGURE 3. At Station I, bottom sediments including fine grained sand loden with organic matter, courser sand and shell debris, covered most of the bottom. Sediments ranged between 1 and 10 cm in thickness. The filter feeders *Muricea californica* and *Pachycerianthus* sp. were abundant. *Photograph by R. Grigg.*

if not caused directly by toxic waste products, may indicate that relief is more important as a substrate for food rather than a source of shelter or a point of orientation.

In Los Angeles and Long Beach harbors which are protected from wave activity, Reish (1959) considered the most important factors eliminating algae to be toxic effects of pollutants, elimination of suitable substrates, and decreased productivity resulting from increased water turbidity. It is not known to what extent toxic pollutants and increased turbidity affect marine life at White Point; however, where deposits of fine grained organic laden sediments do accumulate, the modification or elimination of suitable substrates appears to be a major factor reducing the diversity of epibenthic communities on rocky bottoms.

ACKNOWLEDGMENTS

We wish to thank John McGowan for stimulating this work; E. W. Fager for critically reading the manuscript; John Prescott for providing launching facilities at Marineland of the Pacific; Wheeler North, Charles Turner, Rim Fay, and Donald Reish for stimulating discussions; Virginia Moore for preparing the figure; and Linda Merritt for typing the manuscript.

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Calif. Fish and Game, 56 (3) : 156–165, 1970.

DIVERSITY IN FEEDING BY BRANDT'S CORMORANT NEAR SAN DIEGO[1]

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Brandt's cormorants feed on diverse assemblages of fish species, in a wide variety of habitats. They feed in dense kelp beds and in open water; in midwater; on the bottom, sometimes rather deep; and near the surface. Each day the birds move out en masse from fixed roosts. Mass flights to different feeding areas may be abruptly alternated on a time scale of a few days. This species, like some other cormorants, sometimes feeds singly or in small groups, often mixed with other bird species; but at times feeds in huge compact rafts of seemingly frantic birds, all of this species. These rafts move, apparently following schools of fish, by the repeated flight of groups of birds from the trailing edge to the very front of the raft. Both large and small fish are consumed, most of which are of limited commercial significance. Cormorants are very accomplished underwater swimmers, making use of their feet only.

INTRODUCTION

Studies carried out over the past 25 years in the vicinity of San Diego, California, indicate sharp diversity in the feeding habitats and food of Brandt's cormorant, *Phalacrocorax penicillatus* (Brandt). Though incidental and intermittent, the field observations and food analyses show that this cormorant feeds effectively in several distinct habitats, wherein different assemblages of fish species are consumed.

The vernacular names of fishes follow "A List of Common and Scientific Names of Fishes from the United States and Canada," American Fisheries Society Special Publication No. 2, 1960, in conformity with the editorial policy of this journal.

The diversity in feeding behavior of Brandt's cormorants was impressed on one of us (C.L.H.) in 1944–48, when he almost daily watched the movements of this species from and to their crowded roost on the nearly vertical cliffs between and above the famed La Jolla Caves (Williams, 1942; Martini, 1966). Most of the observing was done with binoculars from Scripps Institution, approximately 1 mile north of the Caves, on the coast in the northern part of San Diego.

In those happy years, before the swarming activities of man and the alarming increase in the pollution of coastal waters by pesticides and other pollutants, approximately 2,000 cormorants, about 99% Brandt's and 1% double-crested, *Phalacrocorax auritus albociliatus* Ridgway, occupied this rookery. In this very picturesque habitat, they provided a prime attraction that has dwindled almost to the level of disappearance. Strikingly marked reduction was observed as early as May 1961, when the cliffs were utilized largely by western gulls, *Larus occidentalis* Audubon. Brandt's cormorants soon returned in moderate numbers, with some seasonal fluctuations in comparison with the other

[1] Contribution from Scripps Institution of Oceanography, University of California, San Diego. Accepted for publication February 1970.
[2] Deceased 1960.

species of cormorants and other sea birds, as noted for 1962 by Martini (1966), who gave a maximum estimate of about 400 Brandt's cormorants on the Caves cliff.

In the 1940's, Brandt's cormorants crowded onto every available ledge to which a bird could cling on the nearly vertical cliff face. Considerable numbers nested, though there were not nearly enough suitable ledges to provide nesting sites for all. That many did nest here seems an exception to the rule stated by Jared Verner (*in* Palmer, 1962) that this species nests "almost always on sloping (not precipitous) surfaces." As Williams (1942) noted, this sheer-cliff nesting at La Jolla on an exceptional mainland site contrasts with nesting on a less steep base on inshore rocks. On the La Jolla cliff there is sloping ground, with low bushes, on the rim of the Caves cliff; but, as noted by Michael (1935) and Martini (1966), this area was monopolized by the much smaller population of double-crested cormorants. The two species foraged, roosted, and nested separately. We have observed similar habitat segregation on the cliffs of northwestern Baja California. There is, in general, a contrast in the feeding areas along the Baja California coast: Brandt's cormorants feed mostly along the more rugged coast with stronger surf; double-crested cormorants more in bays, lagoons, and the more protected open coast.

In recent years, double-crested cormorants have come to roost on power lines crossing the San Diego River floodway just south of Mission Bay in San Diego. Earlier, double-crested cormorants in San Francisco Bay adopted the same bizarre roosting habit (Bartholomew, 1943). No Brandt's cormorants seem to have acquired this habit.

FEEDING FLIGHTS

The Brandt's cormorants returned before dark to the La Jolla Caves cliff from their daily feeding forays, singly or in generally small groups, filling before dark every available little ledge, commonly with considerable aggressive behavior (Williams, 1942). At a very regular time in the morning, varying somewhat with degree of overcast, the birds took off for their feeding areas; at first usually singly or in small groups, but soon in rapid procession. Areas of the cliff first struck by the early morning sunlight were usually the first to be vacated. Groups took off by swooping outward and downward nearly to the ocean surface. They then promptly formed into single files or V's.

Ordinarily for several successive days the Brandt's cormorants all flew outward, then westward to off Point La Jolla where vast beds of giant kelp, *Macrocystis pyrifera* (Linnaeus), then flourished, providing a rich supply of fish (Limbaugh, 1955; Quast, 1968). Here the feeding rafts tended to be broken up, probably because the surface canopy of kelp was in large, very dense patches and feeding by the birds was largely confined to openings in the kelp bed.

Occasionally the whole colony of birds flew to the outer part of La Jolla Bay, where, in clear view from Scripps Institution, they accumulated in a huge, dense feeding raft of excessively active birds, seemingly frantic in their diving, surfacing, and splashing—much like the activity described by Bartholomew (1942) for the double-crested cormorant in San Francisco Bay. In La Jolla Bay the whole raft kept moving in one direction, apparently following a school of fish. The progression

was accomplished not by a mass movement of the whole raft, but by groups of rear stragglers almost continuously taking off to fly entirely over the whole mass to alight directly in front of the leading edge, seemingly in the midst of the fish school, wherein they immediately started fishing. In this way, the birds in the least favorable fishing spot suddenly attained the prime position, very soon to be demoted into second place when the next flight landed in front of them. In this feeding area, it is almost certain that such schooling fish as anchovies or sardines were being consumed—species quite different from those in the kelp bed or in the other feeding areas now to be described.

After heading unerringly for several successive days into the kelp beds, the entire colony of the La Jolla Caves cliff would, without any apparent stimulus or hesitation, head due north to continue up the straight coastline to feeding grounds off the open, sandy shore, at various places from near Del Mar to near Oceanside; a round trip of roughly 10 to 50 miles. The birds in this area fed on fishes that characteristically live flush on the bare sandy bottom, well beyond the tidal zone and out to depths of probably 50 meters. Here the fish fauna (Ford, 1965) is quite distinct from that of the midwater habitat in the underwater forests of kelp—or from that of the near-surface waters where the rafting behavior was noted. Often for several successive days the entire colony of Brandt's cormorants unhesitatingly took off for the northern grounds, before abruptly reverting, again for no obvious reason, to flying the short distance westward to the kelp beds. Such mass behavior poses a real problem to behaviorists.

On the northward flight, the vanguard would proceed in small files, close to the surface, about 2,000 meters offshore. As the numbers rapidly built up, some of the files became V-shaped, and some occasionally overlapped. The regularity in filing northward made it possible to make a rather precise count (about 2,000) of the entire colony, from the cliff at Scripps Institution. In the return movement, the birds were much more scattered, in time as well as in space. They generally flew close to the surface; but as they approached the cliff, especially in foggy weather, the entire file of birds would occasionally rise in the form of a progressive wave to a height of about 10 meters, as though to look ahead.

From a roost on a cliff on the ocean side of Point Loma, also in San Diego, Brandt's cormorants have been seen moving out toward feeding grounds either in the adjacent kelp bed, where one bird containing typical kelp fishes was shot, or into San Diego Bay, where it is presumed food was taken, probably representing still another assemblage of species.

KELP-BED FEEDERS

Eight food-containing Brandt's cormorants, six from the La Jolla kelp bed and one each from the kelp beds off Point Loma and south of Islas Los Coronados (Table 1), were assumed to have fed in the kelp beds. Their stomachs contained fishes that characteristically live in midwater, often almost exclusively among the fronds of *Macrocystis* (Limbaugh, 1955; Quast, 1968). These 8 birds contained 33 fish specimens representing 5 species in as many genera and in 4 families, as follows:

Señorita, *Oxyjulis californica* (Günther), family Labridae (wrasses), one of the dominant species in the kelp-bed community: 17 from near La Jolla, 3 from near Islas Los Coronados, 1 from off Point Loma.

Blacksmith, *Chromis punctipinnis* (Cooper), family Pomacentridae (damselfishes), abundant in the kelp: 5 from near La Jolla.

Kelp perch, *Brachyistius frenatus* Gill, family Embiotocidae (viviparous perches), another fish abundant in the kelp beds (Hubbs and Hubbs, 1954) and essentially endemic to this habitat: 3, 40–50 mm SL, from near Islas Los Coronados, 2 from off Point Loma.

White seaperch, *Phanerodon furcatus* Girard, family Embiotocidae, rather common in kelp and other inshore habitats: 1, from near La Jolla.

Vermillion rockfish, *Sebastes miniatus* (Jordan and Gilbert), family Scorpaenidae (scorpionfishes), one of the few rockfishes that swims off the bottom, occasionally living in the kelp, especially when young: 1 young, 69 mm SL, from near Islas Los Coronados.

TABLE 1

Food of Individual Brandt's Cormorants, *Phalacrocorax penicillatus*

Presumed habitat of feeding Where and when collected	Sex of bird	Fish species (no.)	Vol. (ml)
In or near beds of giant kelp (*Macrocystis*)			
Kelp bed 1 mi. off La Jolla, IV:28:52	M	*Chromis punctipinnis* (1) *Oxyjulis californica* (4)	50
Outside kelp bed off La Jolla Caves, V:8:52	M	*Phanerodon atripes* (1) *Oxyjulis californica* (1)	110 30
1.5 mi. off La Jolla Caves, flying over kelp bed, V:30:52	M	*Chromis punctipinnis* (1)	140
La Jolla Caves area, VI:2:52	M	*Chromis punctipinnis* (1)	60
Off La Jolla Caves, VI:2:52	M	*Chromis punctipinnis* (2)	--
	F	*Oxyjulis californica* (9)	40
Off Point Loma, I:25:55	M	*Brachyistius frenatus* (2) *Oxyjulis californica* (1)	--
1.5 mi. S. of South Island, Islas Los Coronados, VIII:4:69	F	*Brachyistius frenatus* (3) *Oxyjulis californica* (3) *Sebastes miniatus* (1)	4.5 8.0 5.6
Sandy bottom off beach			
Off Scripps Pier, flying S. toward roost at La Jolla Caves, VI:2:52	M	In gular pouch: *Citharichthys stigmaeus* (3) In stomach: *Chitonotus pugetensis* (1) *Citharichthys stigmaeus* (8) *Xystreurys liolepis* (1)	ca. 20 ca. 150
	F	*Citharichthys stigmaeus* (11) *Pleuronichthys decurrens* (1)	160
Miscellaneous material			
Middle Rock, Islas Los Coronados, B. C., Mexico, X:28:52	F	*Atherinopsis californiensis* (1) *Atherinops affinis*? (2)	460
0.5 mi. E. of S. end of South Island, Islas Los Coronados, IX:14:69	M	*Chromis punctipinnis* (1)	11.0
	M	*Brachyistius frenatus* (1)	2.0
	M	*Trachurus symmetricus* (3)	19.3
	M	*Heterostichus rostratus* (1)	40
	M	*Embiotoca* sp. (1) *Oxyjulis californica*(1)	69 3.0

Certain fish species (and various crustaceans and other invertebrates) that are highly characteristic of the *Macrocystis* beds and abound there were notably absent in food samples of the Brandt's cormorants that had been feeding in the kelp. These apparently shunned or overlooked animals are concealingly colored and live on the kelp or close among the fronds. In addition, many are hard and/or spiny. The fishes in this cryptic category are kelp pipefish, *Syngnathus californiensis* Storer;

kelp clingfish, *Rimicola muscarum* (Meek and Pierson); striped kelpfish, *Gibbonsia metzi* Hubbs; giant kelpfish, *Heterostichus rostratus* Girard (Hubbs, 1920); and kelp gunnel, *Ulvicola sanctaerosae* Gilbert and Starks. A giant kelpfish included in the food of one cormorant was probably taken in red algae. All of these species are taken commonly by the kelp harvesters, which utilize the surface canopy of the kelp, though none are commonly visible by scuba diving or from research submersibles operating in the kelp. The circumstances seem to imply that fishing cormorants rely primarily on vision, and feed particularly on fishes in free motion.

SAND-BOTTOM FEEDERS

Two Brandt's cormorants containing a different fish assemblage were collected off Scripps Institution Pier as they were returning from the north toward the La Jolla Caves roost. Because the 25 fish specimens taken in these birds represent species characteristic of the sand-bottom habitat, the birds are assumed to have fed off the sandy beaches to the northward. Four species in as many genera and in three families comprised the food of these two birds:

Speckled sanddab, *Citharichthys stigmaeus* Jordan and Gilbert, family Bothidae (left-eyed flounders), the dominant fish in this habitat, at depths inside the 50-meter contour (Ford, 1965): 22.

Fantail sole, *Xystreurys liolepis* Jordan and Gilbert, family Bothidae: 1.

Curlfin turbot, *Pleuronichthys decurrens* Jordan and Gilbert, family Pleuronectidae (right-eyed flounders): 1, young.

Roughback sculpin, *Chitonotus pugetensis* (Steindachner), family Cottidae (sculpins): 1.

MISCELLANEOUS FEEDERS

Somewhat different and varying feeding habitats, and assemblages of fish species consumed, are represented by two collections taken close to Islas Los Coronados.

One of two Brandt's cormorants taken close to "Middle Rock," the smaller of the two islets between the two main Islas Los Coronados, just south of the international border, contained food. It had obviously been feeding near the surface, where the atherines eaten normally swim. Three specimens, probably of two species, had been eaten:

Jacksmelt, *Atherinopsis californiensis* Girard, family Atherinidae (silversides), a large species: 1 adult.

Topsmelt, *Atherinops affinis* (Ayres), family Atherinidae, a medium-sized species: 2, each about 5 inches long (identification not fully ascertained).

Three of four specimens of Brandt's cormorant taken about 0.5 mile east of the south end of the south island of Islas Los Coronados contained food. Only a few stipes of *Macrocystis* were seen growing here, but some of the birds may have fed in the denser kelp that extends southward from the island. Some fish species commonest in the kelp beds (as noted above) were included, but may have been taken away from the kelp. One open-water species, the jack mackerel, was included, along with a seaperch that is commonest elsewhere (see below). Each bird had eaten two species, of different families:

(1) Blacksmith, *Chromis punctipinnis*, 1 nearly complete, half-grown fish; and kelp perch, *Brachyistius frenatus*, tail end of one, partly digested.

(2) Jack mackerel, *Trachurus symmetricus* (Ayres), family Carangidae, 3 small examples, partial to whole; and 1 giant kelpfish, *Heterostichus rostratus*, a medium-

sized example of this relatively large member of the Clinidae, in the uniform red-brown phase usually found in red algae on the bottom in moderate depths.

(3) Seaperch, *Embiotoca* sp. (probably distinct from *E. jacksoni*), family Embiotocidae, taken in whole and fresh condition beside the shot bird, almost certainly regurgitated, in the reddish phase developed in relatively deep, hard-bottom, open-coast water; and señorita, *Oxyjulis californica*, tail end of one in fresh condition.

Of the Brandt's cormorants shot for food study, only five, four from Islas Los Coronados and one from the La Jolla kelp beds, contained no food.

PUBLISHED ACCOUNTS OF FOOD OF BRANDT'S CORMORANT

Prior determinations of the food of this species of cormorant have been summarized by A. W. Schorger (*in* Palmer, 1962), as follows: "Food largely fishes of no commercial value; also crustaceans," but the fish species identified are Pacific herring, *Clupea pallasii* Valenciennes; cabezon, *Scorpaenichthys marmoratus* (Ayres); and the bocaccio, *Sebastes paucispinis* Ayres, all of some commercial significance. However, the fishes we found that had been eaten were predominantly of minor economic importance. Schorger also reported one crab and some shrimp as food items, but no invertebrate appeared in any of the birds we examined. Gabrielson and Jewett (1940) took a strong stand favoring the conservation of Brandt's cormorant in Oregon, indicating that its food was primarily "trash fish," but gave little solid evidence on its food and economic significance.

Martini (1966) has greatly increased the list of fishes that can be regarded with very high probability as items in the diet of the Brandt's cormorant. These comprise most of the species identified from otoliths in the regurgitated pellets ("Gewöller") of western gulls, *Larus occidentalis*, found on the rocky shore in the immediate vicinity of the La Jolla Caves cliffs, where the Brandt's cormorants roost and often associate with the western gulls. Otoliths are highly resistant and highly distinctive structures. As Martini suggested, it may be assumed that the vast majority of the fish species listed had been caught by Brandt's cormorants. Only a few of the species could conceivably have been captured by the western gull, for they live at depths below those available to a feeding gull. Some of the species, notably Pacific hake, *Merluccius productus* (Ayres), Pacific sanddab, *Citharichthys sordidus* (Girard), pink seaperch, *Zalembius rosaceus* (Jordan and Gilbert), shortbelly rockfish, *Sebastes jordani* Gilbert, sculpin, *Icelinus* sp., and bluespot goby, *Coryphopterus nicholsii* (Bean), probably were taken at depths of 20 to 50 meters, or more. The gulls may have robbed the cormorants either on the joint feeding grounds or on the cliffs, or may have picked up the fish, or even isolated otoliths, on the ledges. The other species of cormorants are much fewer on the cliffs and are less closely associated with the gulls. No other fish-eating birds are likely to have contributed the otoliths to the gulls. An occasional fish may have been picked up on the beach by a gull, but the fish species attributed to the Brandt's cormorant in the following list are very seldom washed ashore. Seasonally, as Martini (1966) noted, Heermann's gulls, *Larus heermanni* Cassin, occupy the same area near the Caves as the western gulls, but he indicated that this species left no pellets here.

In the list below, species indicated in parentheses by *P* are attributable to original capture, in very high probability, by the Brandt's cormorant; those listed as *L* or *P* either to the western gull or this cormorant; a few are attributed to *P*, possibly *L*. The relative numbers by species of fish are: *P*, 17; *P*, possibly *L*, 3; *P* or *L*, 5. By numbers of otoliths (excluding 39 not identified), the ratios are *P*, 402; *P*, possibly *L*, 18; *P* or *L*, 78.

It appears that the majority of the fishes reported by Martini to have been eaten by western gulls in this area originally had been caught by Brandt's cormorants. Most, perhaps all, of the invertebrate food found by Martini in the castings of the western gull, consisting predominantly of goose barnacles, *Mitella polymerus* (= *Pollicipes polymerus* Sowerby), with some mollusks and occasionally crustaceans and echinoderms, as well as refuse, may be attributed to the gulls alone. Goose barnacles also predominated in western gull pellets spewed on Scripps Pier.

Fishes Represented by Otoliths in Castings of Western Gulls near La Jolla Cave Cliff, as Listed by Martini (1966)

The figure listed after each species represents the number of otoliths (all sagittae, except for 4 lapillae attributed to an unidentified embiotocid). The nomenclature of a few species is here modified. Species marked with initial asterisk are not included in our food studies.

Engraulididae (anchovies)
* Anchovy, *Anchoa* sp., probably slough anchovy, *A. delicatissima* (Girard): 1 (*L* or *P*).
* Northern anchovy, *Engraulis mordax* Girard: 53 (*L* or *P*).

Merlucciidae (hakes)
* Pacific hake, *Merluccius productus* (Ayres): 16 (*P*).

Bothidae (left-eyed flounders)
* Pacific sanddab, *Citharichthys sordidus* (Girard): 4 (*P*).
Speckled sanddab, *Citharichthys stigmaeus* Jordan and Gilbert: 11 (*P*). *C. sordidus* or *C. stigmaeus:* 9 (*P*).

Serranidae (sea basses)
* Bass, *Paralabrax* sp., perhaps spotted bass, *P. maculatofasciatus* (Steindachner): 1 (*P*).

Atherinidae (silversides)
* Grunion, *Leuresthes tenuis* (Ayres): 10 (*L* or *P*).
Jacksmelt, *Atherinopsis californiensis* Girard: 1 (*L* or *P*).
Topsmelt, *Atherinops affinis* (Ayres): 13 (*L* or *P*).

Haemulidae (grunts)
* Sargo, *Anisotremus davidsonii* (Steindachner): 1 (*P*).

Sciaenidae (croakers)
* White croaker, *Genyonemus lineatus* (Ayres): 6 (*P*, possibly *L*).

Embiotocidae (viviparous perches)
* Walleye surfperch, *Hyperprosopon argenteum* Gibbons: 7 (*P*, possibly *L*).
Black seaperch (ocean representative), *Embiotoca* sp.: 93 (*P*).
White seaperch, *Phanerodon furcatus* Girard: 144 (*P*).
* Pile perch, *Damalichthys vacca* Girard?: 13 (*P*).
* Rubberlip seaperch, *Rhacochilus toxotes* Agassiz: 4 (*P*).
* Pink seaperch, *Zalembius rosaceus* (Jordan and Gilbert): 4 (*P*).
* Shiner seaperch, *Cymatogaster aggregata* Gibbons (presumably the typical mainland subspecies): 5 (*P*, possibly *L*).
Unidentified embiotocid lapillae, with sagittae of *Embiotoca* sp. and *Phanerodon furcatus:* 4 (*P*).

Scorpaenidae (scorpionfishes)
* Shortbelly rockfish, *Sebastes jordani* Gilbert: 5 (*P*).

Cottidae (sculpins)
* Sculpin, *Icelinus* sp. (probably *I. tenuis* or *I. quadriseriatus*): 2 (*P*).

Gobiidae (gobies)
* Bluespot goby, *Coryphopterus nicholsii* (Bean) : 4 (*P*).
Batrachoididae (toadfishes)
* Plainfin midshipman, *Porichthys notatus* Girard : 50 (*P*).
* Specklefin midshipman, *Porichthys myriaster* Hubbs and Schultz : 3 (*P*).
Ophidiidae (cuskeels)
* Basketweave cuskeel, *Otophidium scrippsi* Hubbs : 22 (*P*).
* Spotted cuskeel, *Chilara taylori* (Girard) : 12 (*P*).

SUPPLEMENTARY OBSERVATIONS

According to the preceding data, Brandt's cormorant has been indicated with certainty, or high probability, to feed in the San Diego area on 35 species of fish that we class in 31 genera and 18 families. These represent a wide variety of the benthic and nektonic fishes that inhabit the littoral waters of the region, on and over the shallower part of the continental shelf. Extended observations on birds during Marine Vertebrate Cruises of Scripps Institution off southern California and Baja California at various seasons indicate that cormorants ordinarily feed close to shore and are very seldom seen beyond the continental shelf. Only a few individuals of this species (and of the double-crested cormorant) occur on Isla de Guadalupe, the oceanic island off Baja California, despite the fact that small fishes abound around the shores of this island.

In La Jolla Bay, as elsewhere, Brandt's cormorants were seen at times feeding in small groups or even singly, as well as in large groups (as described above). Very often they fed in company with gulls, pelicans, and other birds. Occasionally they fed here in definite association with sea lions, *Zalophus californianus* (Lesson). Notes made on January 2, 1948 recounted such feeding behavior. Several cormorants kept associating with small to rather large groups of actively feeding sea lions, while avoiding a large group of merely migrating sea lions in the same area, then shifting to the larger group when it started to feed. The birds would fly over other sea lions to alight in the forward cluster of the most actively feeding of these very efficient fishing mammals. Whether the birds partook of wounded fish or fragments or merely used the feeding sea lions to locate the fish school was not clear. Probably the sea lions and cormorants were feeding on subsurface or midwater fishes. On April 7, 1948, for at least 10 minutes, about 200 cormorants kept flying over a school of feeding sea lions just off the La Jolla kelp, to alight among the most actively feeding mammals.

That the Brandt's cormorants dive at times with sea lions, and that they commonly dive rather deep, are further indicated by records for this species made by one of us (C. L.) during his extensive scuba diving. During one descent they were seen diving with sea lions, two between 30 and 40 ft (9–12 m) and many between 40 and 50 ft (12–15 m), in the north branch of La Jolla Submarine Canyon, on December 31, 1955. Many were seen between 20 and 30 ft (6–9 m) on three dives off Scripps Pier, on December 6–8, 1955, and during one dive at the (submerged) "Rock Pile," south of the south island of the Los Coronados group, on February 28, 1950. Many were seen at depths between 10 and 20 ft (3–6 m) on nine dives off Scripps Institution, on one dive off Point Loma, and on one dive near the sewer outfall of

Tijuana, in Baja California a few miles below the international border, all during January and February, 1956.

Occasionally Brandt's cormorants succumb to feeding on fish affected by "red tide." Thus, large numbers of this bird came ashore sick or dead on September 14–19, 1955, from the feeding grounds between La Jolla and Del Mar, during and following a "red-tide" epidemic. About 30 per mile came on shore near Del Mar. On September 7 and 8 a mass mortality of queenfish, *Seriphus politus* Ayres, had been observed at La Jolla. Probably the cormorants had been feeding on poisoned individuals of this croaker, which is one of the dominant inshore, midwater fish of the region.

Brandt's cormorants seem to be very effective food gatherers. Often a large proportion of those utilizing the La Jolla rookery returned from their daily feeding within a few hours. They eat both large and small fish (Table 1). Many observations of the birds under water show them to be very rapid and flexible swimmers. Their high specific gravity and wettable feathers obviously require little or no expenditure of energy to remain submerged. Propulsion is by foot action only. No underwater use of wings has been observed in watching many individuals from the Scripps Pier and from ships. Observation for several months of a trained cormorant through a large window in an underwater act at Sea World in San Diego has verified the field studies. All of our observations confirm the stand taken by Gabrielson and Jewett (1940), and seem to negate the statement by Dawson (1923) that the wings as well as the feet are used in underwater swimming. That at least occasionally the feet are moved alternately is shown in an underwater photograph of one of the birds in Sea World, that was used for the cover figure of National Geographic Magazine for July, 1969.

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SOME ASPECTS OF THE LIFE HISTORY OF THE SANTA ANA SUCKER, *CATOSTOMUS (PANTOSTEUS) SANTAANAE* (SNYDER)[1]

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The life history of *Catostomus santaanae*, a small fluviatile species of the subgenus *Pantosteus* occurring in the Santa Clara River, California, was studied from April 1968 to August 1969. Peak spawning activity occurred during May and June with a few individuals spawning as early as March and at least as late as July. Fecundity in six individuals ranged from 4,423 to 16,151. The fertilized ova are demersal and adhesive. *C. santaanae* matures at 1+ with only a few individuals reaching the 3+ age-group. A vertebral deformity was observed in up to 3.47% of the individuals in the monthly samples. However, this apparently did not result in a selective disadvantage in terms of survival. The species is well adapted for survival in streams subject to heavy flooding, both in its ability to withstand rapid currents and also in its ability to repopulate rapidly following the loss of a large percent of the population.

INTRODUCTION

The Santa Ana sucker, *Catostomus santaanae* (Figure 1), is the only native catostomid found in the coastal drainages of southern California and is one of the three native primary freshwater fishes in this area. The other two species are the speckled dace, *Rhinichthys osculus*, and the arroyo chub, *Gila orcuttii*. While investigating the systematic relationships of *Gila orcuttii* (Greenfield, MS) and the unarmoured threespine stickleback, *Gasterosteus aculeatus williamsoni* (Ross, 1969), we were able to collect large numbers of *C. santaanae* in the Santa Clara River, Los Angeles County at Soledad Canyon. The purpose of this report is to describe some aspects of the life history of the Santa Ana sucker, which has not been previously investigated.

C. santaanae was first described by Snyder as *Pantosteus santa-anae* from the Santa Ana River near Riverside, California (Snyder, 1908). Smith (1966) amended the specific name to eliminate the hyphen and relegated *Pantosteus* to a subgenus of *Catostomus*. Although the number of individuals in southern California rivers has been greatly reduced by the effects of man (Miller, 1961), *C. santaanae* may still be collected in the Santa Ana River, Orange County, the San Gabriel and Big Tujunga rivers, Los Angeles County, and the Santa Clara River, Ventura and Los Angeles counties.

Miller (1968) suggested that *C. santaanae* was not native to the Santa Clara River; however, this supposition was based on only negative evidence. *C. santaanae* in the Santa Clara River has been influenced in the past by genes from the Owens Valley sucker, *Catostomus* sp. (Hubbs, Hubbs and Johnson, 1943 and Smith, 1966). Thus it is pos-

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sible that the following information on the life history of *C. santaanae* might differ from that of populations in other drainages.

METHODS AND MATERIALS

Specimens were collected monthly from April 1968 to December 1968, with the exceptions of May and August, and from February 1969 to August 1969, with the exception of July, at two separate stations on the Santa Clara River (Figure 2), totaling 3,359 individuals. The first station was located 1½ miles east of the Antelope Valley Freeway offramp on Soledad Canyon Road, just west of Bee Canyon. The river here is from 3 to 6 ft wide and generally less than 1 ft deep during most of the year. The bottom is composed of rock and sand, with very

FIGURE 1. The Santa Ana sucker, *Catostomus santaanae* (male; 77.2 mm SL). *Photography by S. Ross.*

little aquatic vegetation. Seasonal water temperatures varied from 10 to 26 C. The second station was located 4 miles upstream from the first station on Soledad Canyon Road at a U.S. Forest Service Campsite, and was similar to the first station with the exception of increased streamside vegetation.

All specimens were collected with a .087 inch mesh minnow seine, 3 ft by 4 ft long, or a bag seine, 6 ft deep and 20 ft long with ¼ inch stretch mesh wings and a .087 inch mesh bag. They were preserved in 10% formalin and later transferred to 40% isopropyl alcohol. Standard length was measured to the nearest 0.1 mm, using dial calipers.

Annuli were not well defined on the scales and were not used for aging. Otoliths were removed from 50 fish and cleaned in xylene. Otoliths allowed satisfactory age determination for approximately 20% of those examined. The results were related to the length-frequency diagrams. Dry otolith weight for 20 specimens (29–90 mm) was determined using a Mettler balance.

The time of spawning was determined using three techniques: increase of mean egg diameter throughout the season, the maturity index, and the first major appearance of young.

Fecundity estimates were made from samples of ovaries from six fish ranging in size from 77.8 to 158.2 mm. Weight of the fish, standard length, and weights of both the left and right ovaries were recorded. The ovaries were weighed after excess fluid and adhering foreign tissue

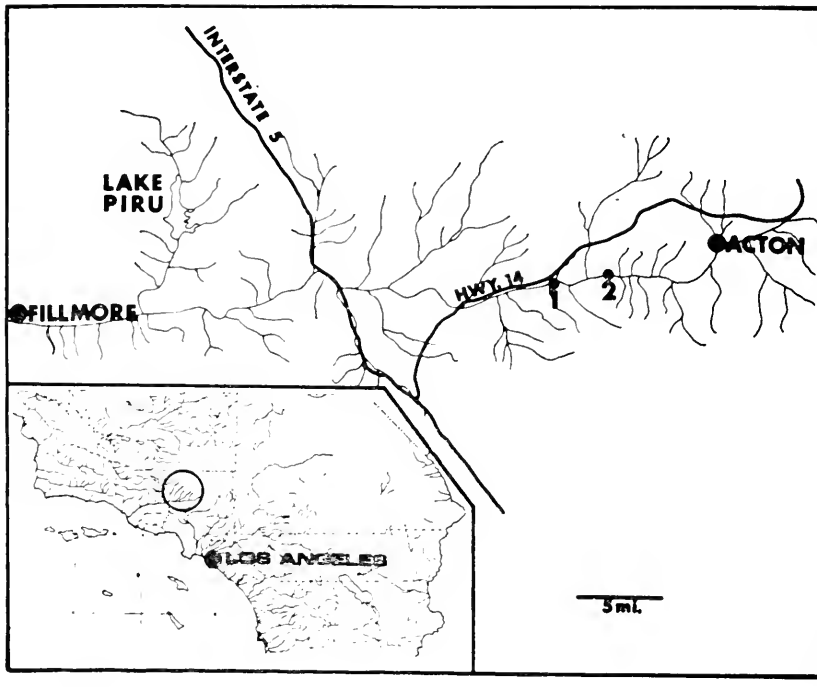

FIGURE 2. Map of study area, showing stations 1 and 2 on the Santa Clara River.

were removed. Samples of eggs were removed at random from each ovary and separated into groups of 150, 100 and 50, while submerged in alcohol to prevent drying. Each of the three samples was dried on absorbant paper prior to weighing to remove excess alcohol. Each sample was weighed on a Mettler balance and the number of eggs per gram computed. An average number of eggs per gram was calculated from the three samples to determine the number of eggs per ovary.

The mean egg diameters for December 1968 and February, March and May 1969 were determined by randomly removing 20 ova per fish from the left ovary of several of the largest females. The ova were arranged in a straight line irrespective of size and viewed with a dissecting microscope equipped with an ocular micrometer.

Thirty-four specimens from the period of June 1968 to May 1969 were utilized to calculate the seasonal trend in the gonadal-somatic, or maturity index $\left(\frac{\text{ovary weight} \times 100}{\text{body weight}}\right)$ (James, 1946). The left ovaries were removed, dried for 4 min on absorbent paper, and weighed. The average maturity index for each month was then calculated and plotted against time to show the progressive increase in relative ovary size up to a peak just prior to spawning.

Stomach contents were obtained from 48 suckers, 27 to 57 mm, collected on October 4, 1968. All specimens were injected with 10% formalin and returned to the laboratory for analysis. The posterior limit of

the stomach was arbitrarily chosen as the middle of the first reverse bend (MacPhee, 1960). Stomach contents were removed to this point and a total wet weight was obtained on the Mettler balance. The organisms were sorted, identified to family, and again weighed according to category. The percentage contribution of each food category to the total weight of the stomach contents was then computed.

Ripe female and male specimens of *C. santaanae* were collected on April 17, 1968, at Station 2, and artificially spawned at 1800 hours. The fertilized ova were brought to the laboratory and hatched in a one-quart jar at 13C. Samples of the various developmental stages were preserved and photographed.

DEVELOPMENT

Development from fertilization until hatching took 360 hours at 13 C. The fertilized ova were demersal and adhesive, averaged 2.2 mm in diameter, and had a transparent egg membrane with a light yellow yolk. The perivitelline space was about one-fifth the diameter of the yolk. Two hours after fertilization the blastodisc had formed and covered approximately one-fifth the diameter of the yolk. At 45 hours after fertilization, epiboly had continued so that the germ ring was slightly less than one-half of the way down the yolk. The embryo was clearly visible at 123 hours and extended three-fourths of the distance around the yolk. The myomeres were visible at 148 hours, and by 171 hours the caudal segment had lifted from the yolk and the embryo exhibited considerable movement. The eyes were pigmented by 315 hours at which time the auditory vesicles were visible. At hatching (360 hours) the prolarva was approximately 7 mm in total length, with the head still bent forward. The pectoral buds were present at this stage. At 26 hours after hatching, the head had straightened out and the dorsal fin fold was visible more anteriorly, originating anterior to the midpoint of the body (Figure 3). A 14.8 mm prejuvenile collected on

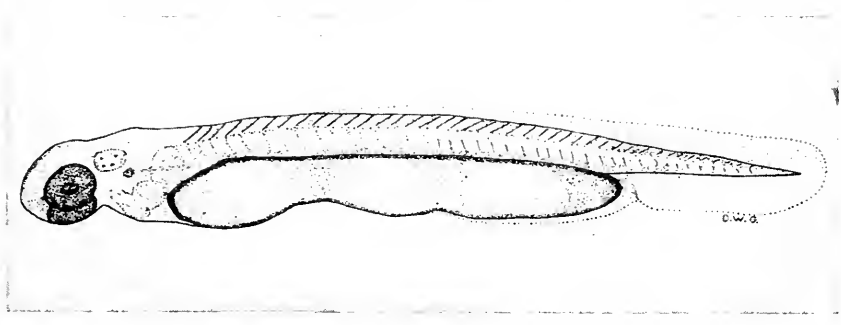

FIGURE 3. Prolarvae 26 hours after hatching (8.9 mm TL). The head has straightened out and both the dorsal and anal fin folds have advanced anteriorly.

June 12, 1968 had remnants of both the dorsal and ventral fin folds still present (Figure 4). The dorsal, caudal and pectoral fins were developed; however, the anal fin was only partially developed and the pelvic fins were represented only by fin buds. The mouth was still terminal. The mouth becomes subterminal at about 16 mm. Pigmenta-

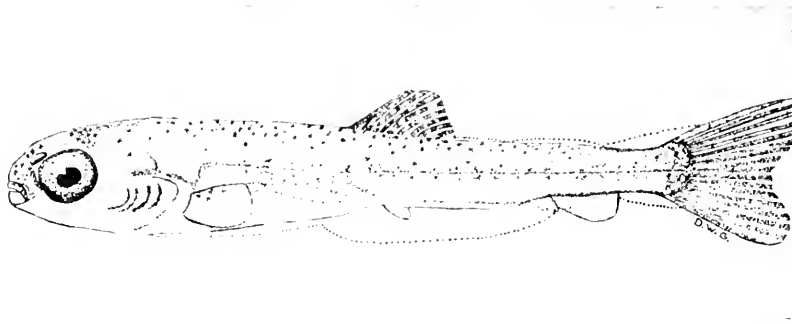

FIGURE 4. A prejuvenile C. *santaanae*, 14.8 mm SL. The dorsal, caudal, and pectoral fins are developed while the anal fin is only partially developed, and the pelvic fins are rudimentary.

tion was heaviest along the dorsal surface, with a diamond shaped concentration of melanophores above the eyes. A line of pigmentation was located laterally at the level of the vertebral column.

FECUNDITY

The total fecundity of six specimens ranged from 4,423 (8.57 g and 77.8 mm) to 16,151 (69.35 g and 158.2 mm) (Figure 5). A linear relationship between body weight and number of eggs was observed. No females under a length of 49 mm or 2.05 g contained eggs.

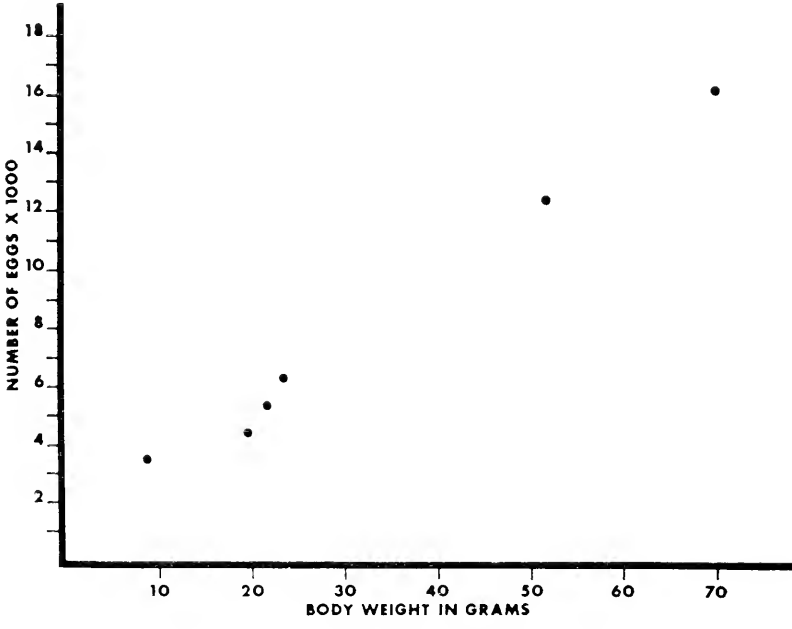

FIGURE 5. The relationship of egg number to body weight for C. *santaanae*.

TIME OF SPAWNING

From our observations the peak of spawning occurred during late May and through June, with the first major appearance of young in early June. The mean egg diameter for December 1968 was 0.10 mm and increased to 1.25 mm in May 1969 (Figure 6). The maturity index was low from June 1968 to December 1968 with a sharp increase after

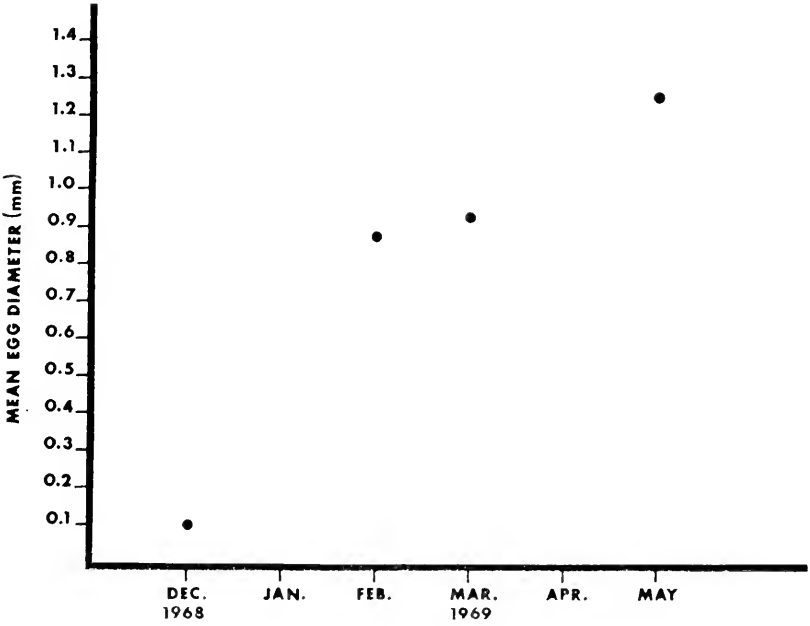

FIGURE 6. The increase in mean egg diameter over a 6-month period.

January 1969 (Figure 7). Only one size group of eggs was found in each ovary. The wide range of variability in the maturity index for February indicates that ova development in some individuals was well advanced at this time. Also, the presence of a few fish 25 mm in April and 31 mm in May of 1968 indicates that some fish had spawned as early as the first week in April. Young fish (10-11 mm) were still present in the July 21, 1968 sample, indicating that spawning had taken place as late as early July. The presence and distribution of breeding tubercles in both the males and females is discussed by Smith (1966).

AGE AND GROWTH

Length frequency data from April 1968 through August 1969 are presented in Figure 8. The 0+ age-group of the 1968 year class was followed from June through December (Figure 9). The mean length of the 0+ age-group in December was 44 mm.

Following Hubbs (1943), the 0+ age-group then becomes the 1+ age-group as of January 1, 1969. Due to the small sample size and the overlap of the size ranges in the 1+, 2+ and 3+ age-groups, mean length values were not determined.

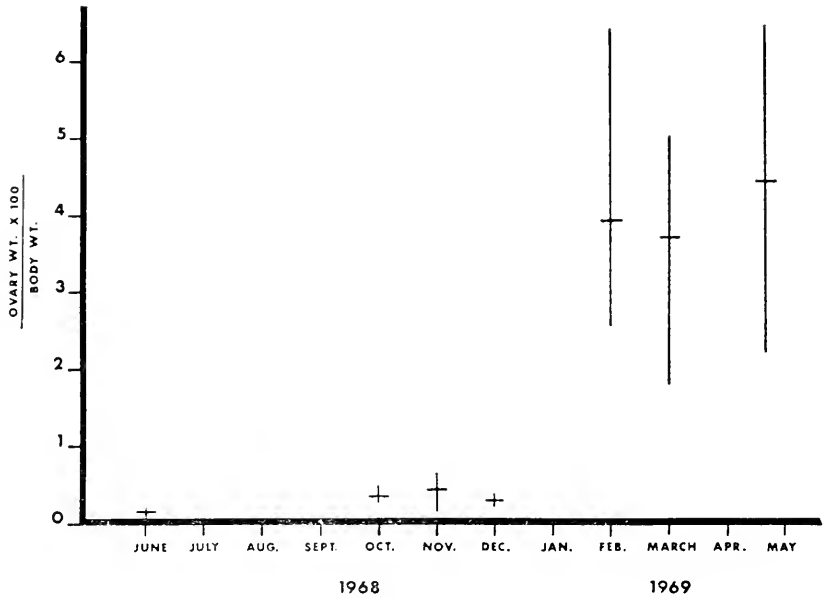

FIGURE 7. The maturity index for a 12-month period beginning after the termination of the 1968 spawning season.

Although scales were unreliable for age assessment due to the lack of conspicuous annuli on even the largest specimens, scale width increased in a linear relationship to standard length (Figure 10), thus allowing an estimation of age from scale width for scales which may be recovered from the stomachs of piscivores.

Otolith growth rings were observed in only 10 out of 50 specimens examined, because the otoliths are extremely small in the Ostariophysi, and they rapidly become spherical with increasing age, thereby inhibiting reading. Age determinations based on otoliths correlated well with expected ages from the length frequency distribution. Specimens 26, 36, 42, and 51 mm from October 1968 were read as being in the 0+ age-group. A specimen 61.5 mm from October 1968 was read as being in the 1+ age-group, while individuals 77 and 83 mm from October 1968 and one 110 mm from December 1968 were in the 2+ age-group. Two large specimens, 141 and 153 mm, collected in February 1969, were members of the same age-group, but since it was past January 1, would be classified as age-group 3+. The relatively large range for the 2+ age-group, 77 to 110 mm, is most likely the result of the prolonged spawning season.

Apparently most fish die while in the 2+ age-group, with a few carrying on into the 3+ age-group. The age and length at maturity data show that spawning first occurs during the spring following hatching at age 1+, and that males and females then spawn a second time the next year while in age-group 2+.

Otolith weight exhibited a curvilinear relationship to standard length, so that it apparently becomes less accurate as an estimate of age after a standard length of about 65 mm (Figure 11).

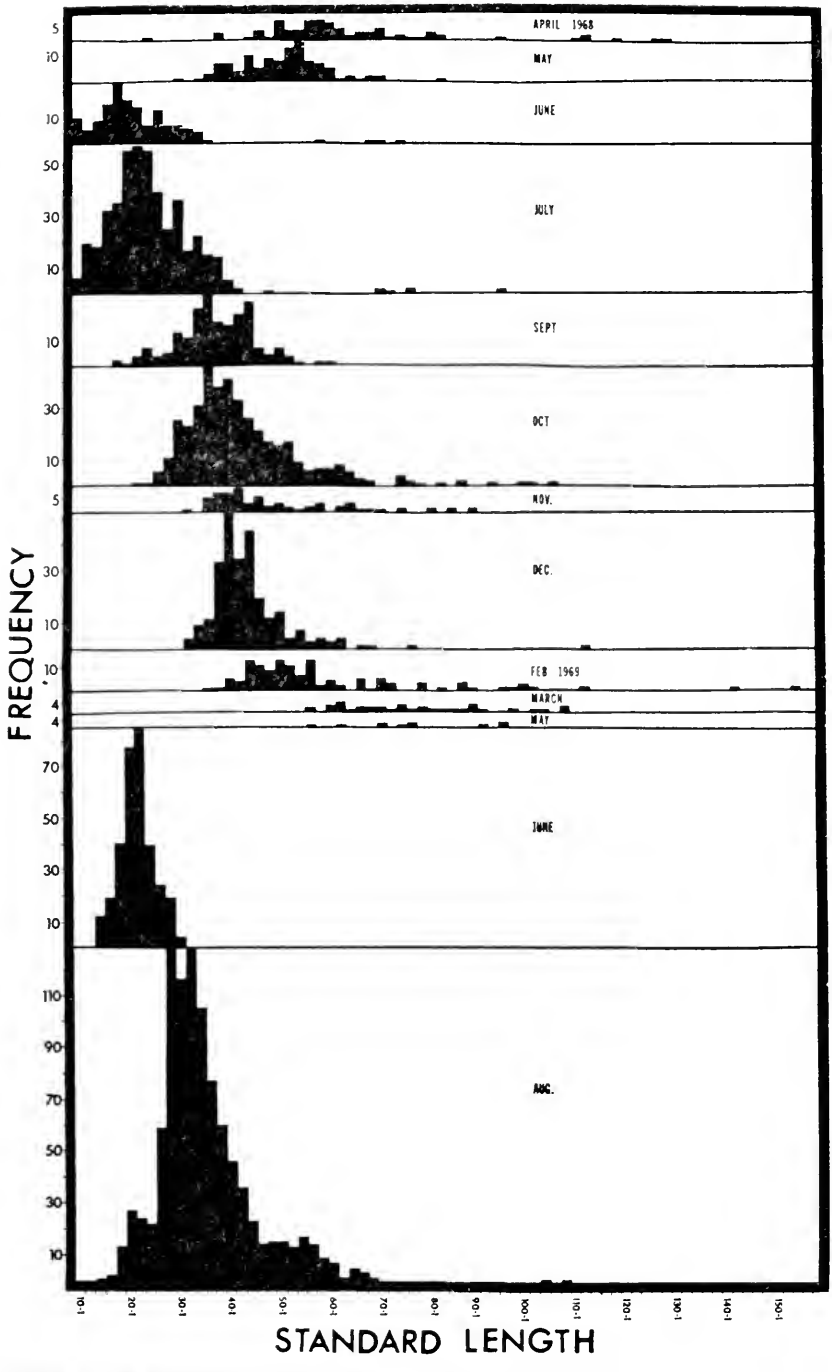

FIGURE 8. Length-frequencies (mm SL) of *C. santaanae* from Soledad Canyon, Santa Clara River from April, 1968 to August, 1969.

Indication of differences in growth rates between the males and females was not found. The sex ratio remained 1 : 1 throughout their life history.

STOMACH CONTENTS

The stomach contents of the 48 suckers examined indicated that 97.53% of the stomach contents by weight consisted of detritus, algae and diatoms, 1.16% of hydrophilid larvae, and the remaining 1.31% larval Plecoptera, Odonata, Helodidae, Hydraenidae, Hydroptilidae, Rhyachophilidae, Empididae and Culicidae, as well as miscellaneous fish scales and eggs. A trend towards an increase in the number of aquatic insect larvae with size was noted.

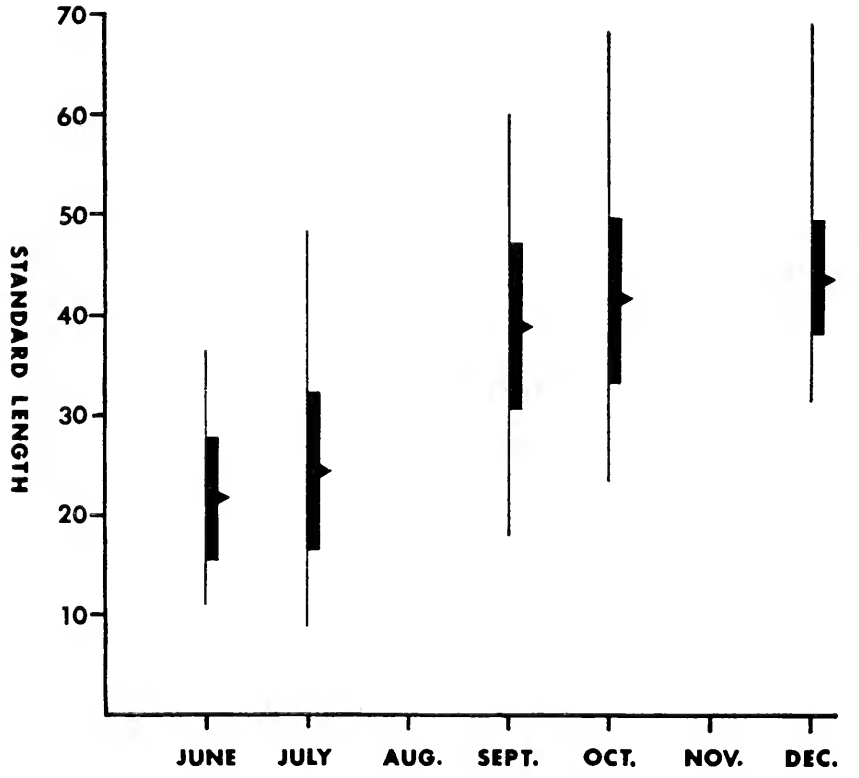

FIGURE 9. Growth curve of the 0+ age-group (mm SL), 1968 year class, of C. *santaanae* from the Santa Clara River. Triangles indicate mean, heavy bars one standard deviation on each side of the mean, and lines, the range.

EFFECTS OF FLOODING ON POPULATION LEVELS

During the winter of 1969 the Santa Clara River flooded in late January and once again in mid-February. One week after the first flood, ½ hour of sampling at each of the two stations yielded 120

C. santaanae as compared to 225 in December. The specimens 141 and 153 mm that were taken in the February 1969 sample were larger than any previously collected. They apparently escaped from a private recreational lake during the first flood. The fact that these two individuals belonged in the same age-group as fish 40 mm shorter suggests that the growth of the river population is slower than that of the pond population.

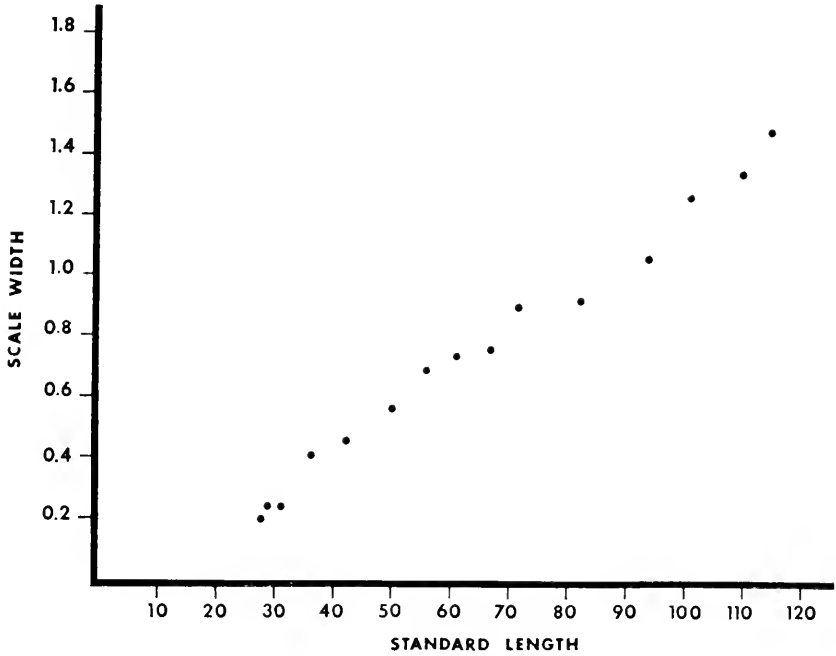

FIGURE 10. Relationship of scale width (mm) to standard length (mm) for C. *santaanae*.

There was a considerable reduction in the numbers of *Gila orcuttii* and *Gasterosteus aculeatus williamsoni* following the floods. The mosquito fish, *Gambusia affinis*, present prior to flooding, has not been collected since the first flood. Numbers of all species remained low until June 1969 (Table 1).

TABLE 1

Numbers of Fishes Collected in the Santa Clara River Subsequent to the 1969 Winter Floods

Date	*Catostomus santaanae*	*Gila orcuttii*	*Gasterosteus aculeatus williamsoni*	*Gambusia affinis*
March 8, 1969	37	0	0	0
April 8, 1969	1	1	0	0
May 13, 1969	10	0	0	0
June 20, 1969	316	15	1	0
August 22, 1969	1,308	9	14	0

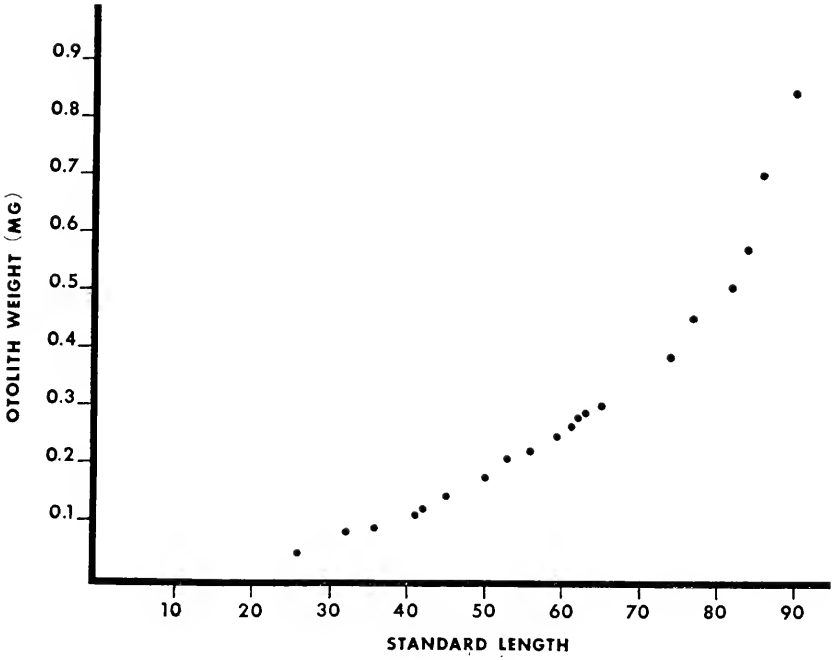

FIGURE 11. Relationship of otolith weight to standard length (mm) for C. *santaanae*.

DEFORMED VERTEBRAE

Throughout the study various individuals were collected which exhibited a vertebral deformity, kyphosis, consisting of an upturn of the vertebral column in the region of the posterior trunk and anterior caudal vertebrae. The percentage occurrence of deformed individuals taken during sampling ranged from 0 to 3.47% (Table 2). In over 60% of the deformed individuals, the centra were crowded and shortened (Figure 12). No difference existed in the number of post-weberian vertebrae between normal and deformed individuals. The counts fell within the range of 39 to 42 presented by Smith (1966) with a median

FIGURE 12. Radiograph of C. *santaanae* (37.2 mm SL) showing typical vertebral deformation.

number of 40. The lack of deformed fish for several months is most likely the result of smaller sample sizes. It is interesting that this deformity was in members of various year classes, indicating that it has been in the population for a number of years.

Amin (1968) reported vertebral kyphosis for *Catostamus insignis* and, to a lesser extent, for *C. clarkii* from the Lower Salt River, Tempe, Arizona. A suggestion was made that a high pesticide concentration might be responsible. However, data on the presence of pesticides in the Santa Clara River are not available. Hubbs (1959) linked vertebral deformities with high water temperatures, a situation which would apply to *C. santaanae* larvae hatched during the latter part of the breeding season. Patten (1968) reported greatly reduced swimming ability in fish with fused or compressed vertebrae. He also stated that increased mortality of the deformed individuals with age was not apparent for *Rhinichthys osculus*. Deformed *C. santaanae* as large as 54 mm were collected in August 1969, indicating that they were able to withstand the flooding conditions. This would indicate that the deformed individuals are not selected against, at least in respect to maintaining themselves in rapid currents. The percentage of deformities for August (1.52) is not significantly lower than other percentages in months prior to the flooding.

TABLE 2

Percentage Occurrence of Deformed Vertebral Columns in *Catostomus santaanae* From the Santa Clara River, California

Date	Number deformed	Total number in collection	Percentage deformed
September 15, 1967	0	24	0
March 27, 1968	0	6	0
April 17, 1968	0	84	0
June 27, 1968	5	144	3.47
July 21, 1968	1	463	0.22
September 3, 1968	5	204	2.45
October 4, 1968	1	262	0.43
November 11, 1968	1	64	1.56
December 18, 1968	4	267	1.49
February 12, 1969	0	21	0
March 8, 1969	0	37	0
May 13, 1969	0	10	0
August 22, 1969	20	1,308	1.52

DISCUSSION

The Santa Ana sucker, *C. santaanae*, seems well adapted to life in small southern California rivers which experience periodic flooding. The rapid repopulation of the Santa Clara River following severe flooding in the winter of 1969 indicates that the relatively few individuals remaining after the flooding were, as a result of their prolonged spawning period and high fecundity, able to return to previous population levels in a single breeding season. The prolonged breeding season would tend to reduce the competition between larval forms and thus more efficiently utilize the available food resources, resulting in an increase in larval survival. The ability to spawn while in the 1+ age-group contributes to the high intrinsic rate of increase for the population.

Spawning by the 1+ age-group is likely also to occur in several other species of the subgenus *Pantosteus* (Smith, 1966), and all species in this subgenus begin spawning at least by the 2+ or 3+ age-groups (Smith, 1966; Hauser, 1969). This is in marked contrast to the larger, more lacustrine suckers of the subgenus *Catostomus*, which generally do not mature until at least age-groups 4–5 (Bailey, 1969; Harris, 1962; Spoor, 1938).

Fecundity is well above the 990 (131 mm TL) to 3,710 (184 mm TL) range reported by Hauser (1969) for *C. platyrhynchus*, also in the subgenus *Pantosteus*. Fecundity for *C. catostomus* was reported by Bailey (1969) to range from 14,000 (352.7 mm TL) to 35,000 (449.2 mm TL). Stewart (1926) reported fecundity for *C. commersonii* to be 31,200 in a 380 mm individual. Both of the above species are in the subgenus *Catostomus*.

The food habits of the smaller members of the 0+ age-group may also enable *C. santaanae* to rapidly repopulate a flooded area, since the young feed primarily on algae, diatoms, and detritus. Aquatic insects become a significant part of their food after they approach the 1+ age-group. The "top-feeding" behavior for prolarvae of *C. macrocheilus* (MacPhee, 1960) was not noted for *C. santaanae* since our food analysis utilized individuals 27 mm or larger, and the shift in feeding habits associated with the movement of the mouth from a terminal to subterminal position and the increased length of the digestive tract had already taken place.

The cause of the vertebral deformity noted in *C. santaanae* is unknown. The effects of predators as an agent in eliminating unfit individuals is also unknown, but there is a lack of larger predatory fish in this river.

The suggestion by Smith (1966) that there might be dual spawning in the spring and fall appears unfounded, while the alternate suggestion of protracted spawning is supported.

ACKNOWLEDGMENTS

We wish to thank all persons who helped with this study. In particular, R. Bagube assisted with the food analysis; J. W. Wiley, R. H. Cornelius, T. Arambula and D. Wildrick helped with the field work. T. Arambula also typed the final manucript.

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DUCK NESTING AND PRODUCTION IN THE HUMBOLDT BAY AREA OF CALIFORNIA[1]

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At Humboldt Bay the nesting season for mallards (*Anas platyrhynchos*) lasted about 145 days in 1964 and 130 days in 1965. The nesting season for cinnamon teal (*Anas cyanoptera*) lasted about 135 days in 1964 and 115 days in 1965. During 1954 to 1966, 49 mallard and 15 cinnamon teal nests were observed. Approximately 53% of the mallard nests and 46% of the cinnamon teal nests were on banks of sloughs or ponds. Nearly 70% of all mallard nests and 80% of cinnamon teal nests were in grasses or grasslike plants. Mallards tended to nest in cover over 25 inches high (63.2% of all nests) while cinnamon teal generally utilized cover less than 24 inches high (86.7% of all nests). Nests of most mallards and cinnamon teal were either completely concealed or had only one side or the top exposed. The average clutch size of nests with eggs which hatched was 9.8 eggs for mallards and 10.8 eggs for cinnamon teal. Hatching success was 65.1% for mallards and 44.0% for cinnamon teal. During 1964 and 1965 the peak of the hatch occurred from early to mid-May for mallards and from late May to early June for cinnamon teal. The size of mallard broods ranged from 9.2 at hatching to 4.6 near the time of flying; for cinnamon teal the range was from 10.7 to 5.8. Estimated duck production was one per 8.1 acres in 1964 and one per 10.2 acres in 1965 in the Humboldt Bay area.

INTRODUCTION

This study was conducted between spring 1964 and early summer 1966 on the Arcata Bottoms near Humboldt Bay, Humboldt County. The objectives were (i) to determine the status and biology of duck nesting (1964 to 1966) and (ii) to estimate duck production (1964 and 1965).

The Arcata Bottoms are situated at the north end of Humboldt Bay (Figure 1), and consist of portions of the Mad River delta and reclaimed bay tidelands.

The 2,432-acre study area contained four land-use types. Permanent pasture occupied 1,761 (72.4%) acres. Hay was cut from 511 (21.0%) acres. The hay crops consisted of perennial grass pastures, from which livestock had been removed temporarily, and of fields planted to annual grass and grain crops. Sloughs, borrow pits along dikes, and remnants of tide channels in pastures occupied 131 (5.4%) acres, and dikes, roads, and railroad grades occupied 29 (1.2%) acres.

Sloughs and intermittent marshes in the pastures supported stands of one or more of the following: marestail (*Hippuris vulgaris*), sago pondweed (*Potamogeton pectinatus*), alkali bulrush (*Scirpus robustus*), three-square bulrush (*S. americanus*), spike rush (*Heleocharis macrostachya*), saltgrass (*Distichlis spicata*), marsh pennywort (*Hy-*

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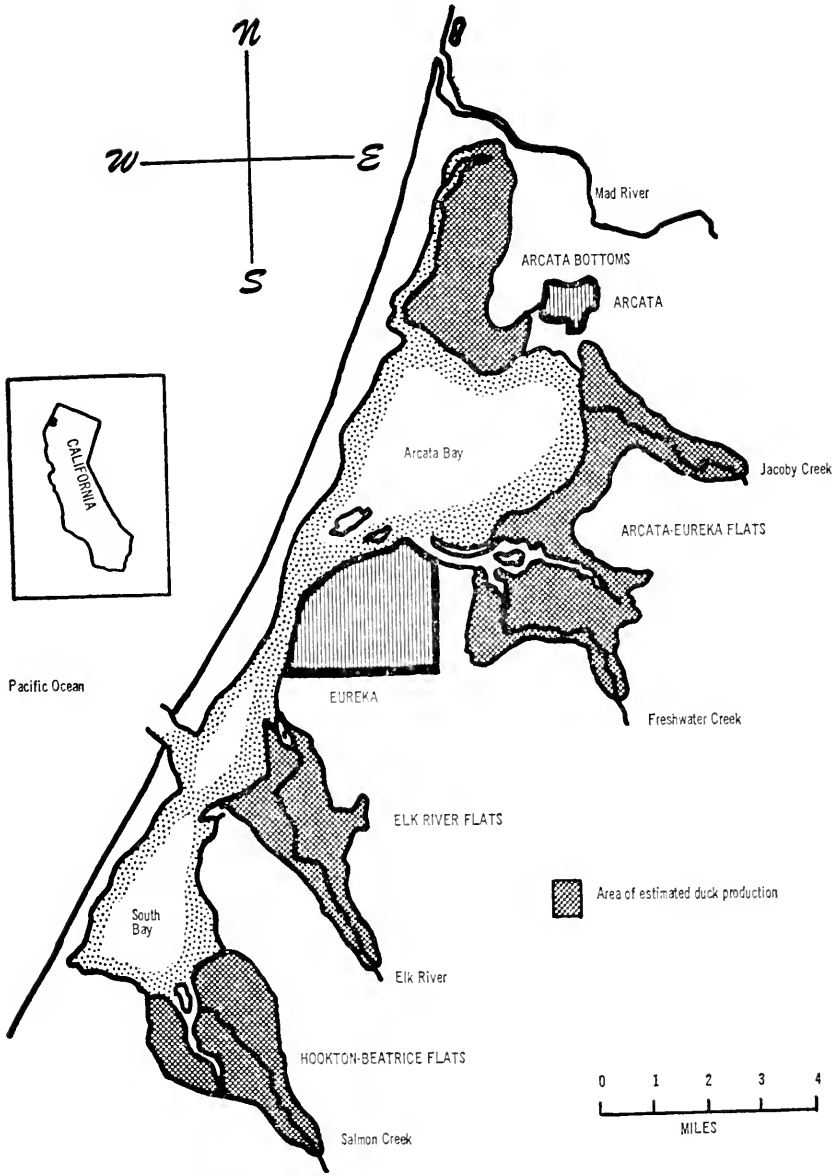

FIGURE 1. Location map of Humboldt Bay and vicinity, showing duck nesting areas.

drocotyle ranunculoides), cattail (*Typha latifolia*), arrow grass (*Triglochin maritima*), rush (*Juncus* spp.), water cress (*Rorippa Nasturtium-aquatica*) and horsetail (*Equisetum* spp.).

Important plants in pastures included orchard grass (*Dactylis glomerata*), velvet grass (*Holcus mollis*), fescues (*Festuca* spp.), sedges (*Carex* spp.), and rushes. Dikes contained mixtures of grasses, shrubs,

and herbs, including tufted-hair grass (*Deschampsia caespitosa*), coyote brush (*Baccharis pilularis*), blackberry (*Rubus vitifolius*), twinberry (*Lonicera involucrata*), lupines (*Lupinus* spp.), mustards (*Cruciferae*), and docks (*Rumex* spp.).

Areas of similar habitat in the Humboldt Bay area occur on the flats between Arcata and Eureka, along the lower Elk River, and on flats bordering the southeast side of South Humboldt Bay (Figure 1).

The Humboldt Bay area is important to wintering and breeding populations of waterfowl (Denson and Bentley, 1962; Yocom and Denson, 1962). Mallards and cinnamon teal (Dollahite and Anderson, 1952) are common breeding species in the habitat types studied. Other species that occasionally or rarely breed in the general area include wood ducks (*Aix sponsa*), American mergansers (*Mergus merganser*), pintails (*Anas acuta*) (Yocom, 1957), shovelers (*Anas clypeata*) (Yocom, 1961), and probably blue-winged teal (*Anas discors*) Harris and Wheeler, 1965; Wheeler, 1965).

METHODS

Random searches were conducted to locate nests. Data were recorded on a form similar to one used by Williams and Marshall (1938). Each nest was marked with a stake 2 to 3 yards away. All nests were revisited at intervals of 10 to 14 days until the fate of the nest was determined.

Brood sloughs, those having possible value for duck production, and ponds were searched regularly on foot with the aid of a Labrador retriever. The age of broods was estimated (Gollop and Marshall, 1954) and notes were made concerning species, presence of female, brood size, completeness of count, ecological and geographical location, and type of cover used. Detailed methodology and data are recorded in Wheeler (1966).

NESTING

Breeding Season

Mallards are on the study area during the entire year. Some mallards were paired by early fall, and by March most were paired.

Cinnamon teal appeared in late January (first bird, January 28, 1965) or early February (first bird, February 8, 1964). Teal became common after early March each year and most were paired by mid-April.

Based on brood ages, the nesting season for mallards lasted approximately 145 days in 1964 and 130 days in 1965. In 1964, 155 mallard broods were aged and in 1965, 136 broods were observed. The earliest mallard brood hatched in late March during both years, and the latest brood hatched during the week of July 9, 1964, and during the week of June 23, 1965.

The nesting season for cinnamon teal, based on brood ages, lasted approximately 135 days in 1964 and 115 days in 1965. In 1964, 42 teal broods were aged and in 1965, 26 broods were observed. The earliest teal brood hatched in late April (1964) and early May (1965), and the latest brood hatched in mid (1965) to late (1964) July.

Nest Sites

Nests were found in four ecological locations: on banks of sloughs or ponds, on dikes, in fields, and over water.

Bank of Slough or Pond

This type of nesting habitat included all areas within 6 ft of the water in sloughs and ponds. Sloughs were 6 to 15 ft wide and consisted primarily of borrow pits along dikes and old tide channels in pastures. Twenty-six (53.1%) of 49 mallard nests and seven (46.7%) of 15 cinnamon teal nests were on banks of sloughs or ponds.

Dike

Dikes and similar structures, such as roadsides and railroad grades, contained 15 (30.6%) mallard nests and 1 (6.7%) cinnamon teal nest.

Field

Four (8.2%) mallard nests and five (33.3%) cinnamon teal nests were in fields and pastures.

Over Water

Portions of some lowland pastures held approximately 6 inches of temporary water early in the nesting season, and four (8.2%) mallard nests and two (13.3%) cinnamon teal nests were over water in clumps of rushes in such areas.

Nest Cover Types

The dominant cover plant was recorded at each nest site. Twenty (40.8%) mallard nests and four (26.7%) cinnamon teal nests were in stands of tufted-hair grass (Table 1). Most stands of this grass occurred on or near dikes or at borders of sloughs. Eleven (22.4%) mallard nests and four (26.7%) cinnamon teal nests were in clumps of rush, and three cinnamon teal nests were in saltgrass (Table 1).

TABLE 1

Dominant Cover Used by Nesting Ducks, Arcata Bottoms, Humboldt County, California, 1964–66

Cover type	Mallard		Cinnamon teal	
	Number of nests	Percentage total nests	Number of nests	Percentage total nests
Grasses and grasslike plants				
Deschampsia caespitosa	20	40.8	4	26.7
Juncus spp.	11	22.4	4	26.7
Other grasses (3 species)	3	6.1	4	26.7
Shrubs				
Rubus vitifolius	6	12.2	--	--
Forbs (5 species)	9	18.4	3	20.0
Total nests	49	--	15	--

Nest Cover Height, Concealment, and Distance From Water

Mallards tended to nest in tall cover, but cinnamon teal selected short to moderate cover. Thirty-one (63.2%) mallard nests were in cover over 25 inches high, but only 2 (13.3%) cinnamon teal nests were in such cover (Table 2).

TABLE 2

Height of Nest Cover, Arcata Bottoms, Humboldt County, California, 1964–66

Cover height in inches	Mallard		Cinnamon teal	
	Number of nests	Percentage total nests	Number of nests	Percentage total nests
0–12	1	2.0	6	40.0
13–24	17	34.7	7	46.7
25–36	28	57.1	2	13.3
Over 36	3	6.1	--	--
Total nests	49	--	15	--

Concealment ratings were assigned to all nests (Miller and Collins, 1954). Forty-seven of 49 mallard and 13 of 15 teal nests were either completely concealed or had only one side or the top exposed.

Twenty-nine (59.2%) mallard nests were within 6 ft and 9 (60.0%) of the teal nests were within 3 ft of water.

Clutch Size

The average clutch size of 28 hatched mallard nests for which complete data are available was 9.8 eggs (range 6 to 13) and for cinnamon teal 10.8 eggs (range 10 to 13) for 6 nests. This compares favorably with the results of Miller and Collins (1954) and Hunt and Naylor (1955).

Nest and Egg Success

In the 3 years, 30 (65.2%) of 46 mallard and 6 (42.8%) of 14 cinnamon teal nests hatched at least one egg. Previous workers reported nesting success ranging from 11.4% to 85.2% for mallards and from 1.8 to 80.0% for cinnamon teal (Girard, 1941; Miller and Collins, 1954; Anderson, 1956, 1957, 1960; Rienecker and Anderson, 1960).

Mallards had a hatching success of 65.1% and cinnamon teal 44.0% (Table 3). Earl (1950), working in the Sacramento Valley, reported a hatching success of 49.4% for mallards and Miller and Collins (1954), in studies at Tule Lake and Lower Klamath National Wildlife Refuges, reported a hatching success of 91.4% for mallards and 88.4% for cinnamon teal. Williams and Marshall (1938) reported an egg success of 60% for mallards and 84% for cinnamon teal at Bear River National Refuge, Utah.

BROOD STUDIES AND PRODUCTION

The peak of the hatch for mallards occurred from early to mid-May and for cinnamon teal from late May to early June. Previous workers in Central California reported similar hatching peaks (Earl, 1950; Anderson 1957, 1960), but workers farther north and in the Great

TABLE 3

Fate of Duck Eggs, Arcata Bottoms, Humboldt County, California, 1964–66

	Mallard (46 nests)		Cinnamon teal (14 nests)	
	Number of eggs	Percentage total eggs	Number of eggs	Percentage total eggs
Hatched	265	65.1	59	44.0
Dead embryo	7	1.7	--	--
Deserted	50	12.3	40	29.9
Infertile	7	1.7	6	4.5
Destroyed	78	19.2	29	21.6
Total eggs	407	--	134	--

Basin reported peaks 2 to 4 weeks later for both species (Williams and Marshall, 1938; Harris, 1954; Rienecker and Anderson, 1960).

The average brood size of mallards in both years ranged from 9.2 ducklings in hatched nests to 4.6 ducklings at 7 to 8 weeks of age, a decline of approximately 50% (Table 4). Most of the loss occurred during the first 4 weeks of life.

The average brood size of cinnamon teal in both years ranged from 10.7 ducklings in hatched nests to 5.8 ducklings at 5 to 6 weeks of age, a decline of 40 to 50% (Table 4). Causes of brood mortality are unknown.

TABLE 4

Average Size of Duck Broods From Time of Hatching Until the Last Age Interval Before Flying, Humboldt Bay Area, Humboldt County, California, 1964–65

(Numbers in Parentheses Represent Number of Broods)

Age in weeks	Mallard			Cinnamon teal		
	1964	1965	Av.	1964	1965	Av.
Hatched nests	9.0(4)	9.3(7)	9.2	10.0(1)	11.0(3)	10.7
1–2	7.9(21)	8.3(16)	8.1	7.7(8)	8.1(5)	7.8
3–4	5.8(13)	6.7(11)	6.2	6.8(6)	7.4(5)	7.1
5–6	4.9(9)	5.6(7)	5.2	5.7(3)	5.9(3)	5.8
7–8	4.4(9)	4.8(6)	4.6	--	--	--

Production

An estimate of broods was made by censusing all brood habitat repeatedly and carefully aging all broods seen, eliminating those old enough to have been tallied on a previous count (Blankenship et al., 1953). It was assumed that all broods produced were observed. Within the study area, mallards produced an estimated 73 broods in 1964 and 65 in 1965, and cinnamon teal produced an estimated 31 broods in 1964 and 13 in 1965. An examination of U.S. Geological Survey topographic maps indicated that there were 19 linear miles of brood sloughs within the 2,432 acres comprising the study area. A "brood slough" was defined as one having possible value for duck production. Large

tidal sloughs such as Mad River Slough were not used in calculating linear miles of sloughs. Old tide channels on reclaimed Humboldt Bay lands, borrow pits along dikes, and small creeks constituted the bulk of the linear mileage and were collectively termed "sloughs". Some sloughs were subject to tidal action, but most were not.

It is estimated that on the study area, 3.8 mallard broods (16.7 ducklings) and 1.6 cinnamon teal broods (9.1 ducklings) were produced per linear mile of slough in 1964, and 3.4 mallard broods (16.3 ducklings) and 0.7 cinnamon teal broods (4.1 ducklings) per mile of slough in 1965.

Estimate of Duck Production in Total Humboldt Bay Area

Production data from the Arcata Bottoms study area were used to estimate duck production for the entire Humboldt Bay area (Figure 1). In the Humboldt Bay area there were approximately 11,200 acres of habitat similar to the Arcata Bottoms study area. This habitat contained approximately 54 linear miles of brood slough. Assuming that broods were produced at the same rate per mile of brood slough in other portions of the Humboldt Bay area as in the Arcata Bottoms study area, an estimated 902 mallards and 491 cinnamon teal were reared to near flying stage in 1964, and 880 mallards and 221 cinnamon teal were produced in 1965 (Table 5).

TABLE 5

Estimated Duck Production, Humboldt County, California, 1964–1965

	Estimated number of broods produced		Estimated number of ducklings produced		Acres per duck	
	1964	1965	1964	1965	1964	1965
Mallard	205	183	902	880	12.4	12.7
Cinnamon teal	86	38	491	221	22.8	50.7
All ducks	291	221	1,393	1,101	8.1	10.2

Earl (1950) indicated that production of ducks, mostly mallards, on irrigated farmland in the Sacramento Valley was approximately 1 duck per 15 acres. Using data presented by Anderson (1957), rough estimates of production rates for the Sacramento Valley range from 1 duck per 36 acres, calculated from breeding pair counts, to 1 duck per 9 acres, calculated from nesting surveys on study areas. At Tule Lake and Lower Klamath Refuges, total duck production was 1 duck per 0.9 acres (Rienecker and Anderson, 1960). Evans and Black (1956) reported a rate of 1 duck per 4.5 acres in the prairie potholes region of South Dakota. By contrast, the present study indicates a rate of 1 duck per 8 to 10 acres, equal to or better than Sacramento Valley irrigated farmland, but less than either prairie potholes habitat or at Tule Lake and Lower Klamath Refuges.

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THE WHITE-TAILED KITE IN CALIFORNIA WITH OBSERVATIONS OF THE SANTA BARBARA POPULATION[1]

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Historical evidence suggests the white-tailed kite *(Elanus leucurus majusculus)* in the last 30 years has made a remarkable recovery from near extinction in California. As a consequence of the increase in numbers, white-tailed kite studies are now possible without endangering the species.

A population of white-tailed kites in the Goleta Valley north of Santa Barbara was studied during the period beginning September 1965 through June 1968. This population exhibited marked seasonal fluctuations as determined by systematic observations of communal night roosting and occurrence in suitable habitat. Evidence from food habit studies suggests that kites, at least in this area, are an almost obligate predator on small mammals, most of which are diurnally active. The authors believe that several behavioral attributes exhibited by the species adapt it for exploitation of prey species with fluctuating population densities.

INTRODUCTION

In many ways the fate of the white-tailed kite (Figure 1) in the United States, since the coming of the white man, is typical of many avian predators. Originally the species was much more widespread than now. May (1935) states that kites occurred in California and over much of the southern United States, particularly in Texas and Florida and casually in Louisiana and South Carolina. Further records suggest it once existed in Oklahoma (Bent, 1937). By the 1940's the species was believed extirpated from the southern United States; however in recent years Audubon Christmas counts indicated that kites have made a slight recovery, at least in Texas. Miles (1964) reported a recent record of the species in Alabama.

White-tailed kites occur in parts of Mexico, particularly along the east coast, and in central and northern South America. Although the species appears to be widespread in North and South America, its range is somewhat discontinuous with vast potential habitats from which it is unreported. A subspecies (*Elanus leucurus leucurus*) is in southern South America.

In California, the extent of the species' range prior to 1900 is difficult to assess. Although it is doubtful that the kite was ever abundant throughout California, Cooper (1870) stated that it was abundant among the extensive tule marshes of the Sacramento and other valleys during winter.

By the 1890's accounts suggested that kites were present in fair numbers but somewhat local in their distribution. Grinnell (1898) listed

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them as common residents of the lowlands. Belding (1890) stated they were common residents in the extensive tule marshes along the San Joaquin River.

FIGURE 1. Photograph of white-tailed kite.

By the early 1900's, habitat destruction, indiscriminate shooting, and possibly egg collecting had reduced the population over most of its range in California. Peyton (1915) noted that kites were vanishing.

The period of real alarm was during the 1920's and 1930's when several authors predicted ultimate extinction for the species in California (Pierce, 1928 and Pickwell, 1932). Hoffman (1927) believed that there were no more than 50 pairs in the state. Bent (1937) stated that the species was almost extinct in North America.

During the 1940's white-tailed kites in California showed a slight increase. Grinnell and Miller (1944) stated that populations had shown a slight recovery. Morgan (1948) recorded the first large roost of up to 25 birds in San Diego County. Records of Audubon Christmas counts indicated that numbers continued to increase gradually during the 1950's and significantly during the 1960's. In 1950 less than 5 birds per 100 observers were recorded throughout the state as compared to 20 and 30 birds per 100 observers in 1960 and 1967, respectively.

In 1957 the California Legislature gave the white-tailed kite fully protected status comparable to the California condor (*Gymnogyps californianus*).

The purpose of this report is to (i) review historical accounts and the current status of the white-tailed kite in California (ii) present data on night communal roosting behavior and (iii) give food habits of the species in the Santa Barbara region. These data comprise part of the effort of a three-year study on the population ecology and behavior of this species.

DISTRIBUTION IN CALIFORNIA

The white-tailed kite is typically a bird of lowland regions of open to moderately open country (Figure 2). It is distributed throughout

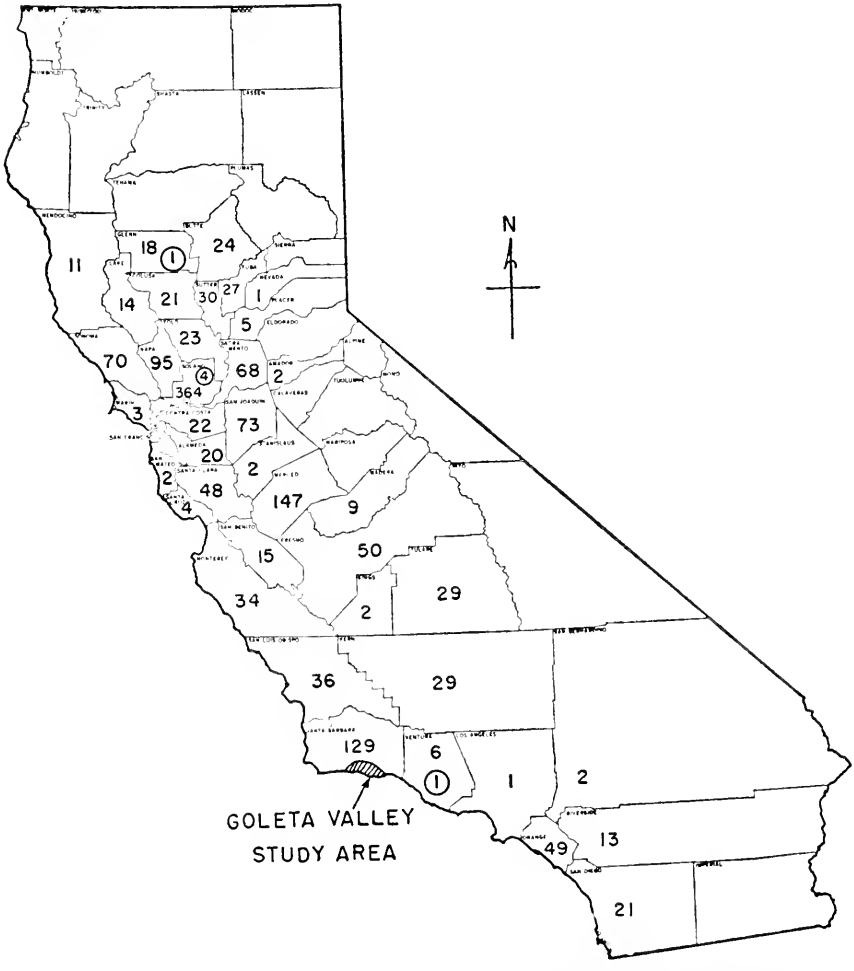

FIGURE 2. White-tailed kite sightings as reported from 1967–68 by California Department of Fish and Game field personnel. Circled numbers indicate nest reports.

much of the Sacramento and San Joaquin Valleys, west through much of the coastal mountain region to the coastal plains. The southernmost breeding record is at Lakeside, San Diego County, and the northernmost at the Eel River Delta, Humboldt County (Gerstenberg, pers. comm.).

The kite inhabits grassland, savanna, fresh-water marsh, salt-water marsh, and riparian woodland of the Upper Sonoran life-zone (Miller, 1951). All these habitats, except riparian woodland have a relatively continuous low ground cover with variable degrees of tree growth. Riparian woodland inhabited by kites consists of rows or substantial clumps of broad-leafed deciduous trees e.g. *Salix* sp. growing on bottom lands near streams, ponds, or other permanent water.

METHODS

A population of white-tailed kites in the Goleta Valley area immediately west of Santa Barbara was under investigation from September 1965 to June 1968. All areas of the valley were systematically checked for population density and movements. Observations were made of the arrival and departure of birds at the communal night roost.

Pellets were collected from the Goleta Valley study area at nest sites, below known perches, and at communal night roost sites. All pellets were measured prior to dissection. Mammal identification was made on the basis of skeletal elements, primarily from tooth remains.

GOLETA VALLEY STUDY AREA AND WHITE-TAILED KITE OCCURRENCE

The Goleta Valley, a narrow coastal plain west of Santa Barbara, is bordered on the north by the chaparral-covered Santa Ynez Mountains, on the south by the Pacific Ocean, and on the east by the city of Santa Barbara. The border areas are unsuitable habitat for the white-tailed kite. The majority of the plain is less than 100 ft in elevation and comprises approximately 22,000 acres of mixed grassland, oak-savanna, marsh, and irrigated and dry croplands. Mean annual precipitation at Santa Barbara is 17.63 inches (30-year record), with great variation between years (range: 3.99–41.48 inches). The wettest months are January and February (7.6 inches) and July and August are the driest (.05 inch). Precipitation is concentrated in a 6-month period from November through April, with very light amounts during the rest of the year. Temperatures are mild along the coast with slight daily and annual ranges. Maximum readings for July average in the upper 60's; January minimums average in the 40's (U.S. Weather Bureau, 1965).

Since 1960 development of the valley has gone forward at an accelerated pace. Orchards, grasslands, marshes, and truck farms have given way to housing developments, shopping centers, and light industry. Long-range plans indicate that a relatively small amount of land will persist as grazing and agricultural lands, Table 1.

Only undisturbed grassland, shrub-savanna, marsh, or areas with cover crops or light grazing provide suitable habitat and support sufficient food supply for kites. The habitat is a patchwork which comprises less than 15% of this coastal plain (in 1966). Areas of moderate to

TABLE 1

Changes in Goleta Valley Land Use, 1961–2000 *

(22,000 acres)

Land use	Year		
	1961	1967	2000
Residential	1,400	3,400	15,300
Industrial	3,300	4,900	5,300
Agricultural	6,700	5,500	0
Rangeland	10,600	8,200	1,400

* From Santa Barbara County Planning Commission.

heavy grazing, while appearing favorable, offer little food supply for this species.

The records of Audubon Society Annual Christmas counts show bird population changes throughout the United States (Audubon field notes 1962–68). These counts cover a 15-mile-diameter area in selected locations. Although the Santa Barbara census area does not correspond directly to our study area, their count reflects marked changes in the white-tailed kite population during 1961–68 (Figure 3).

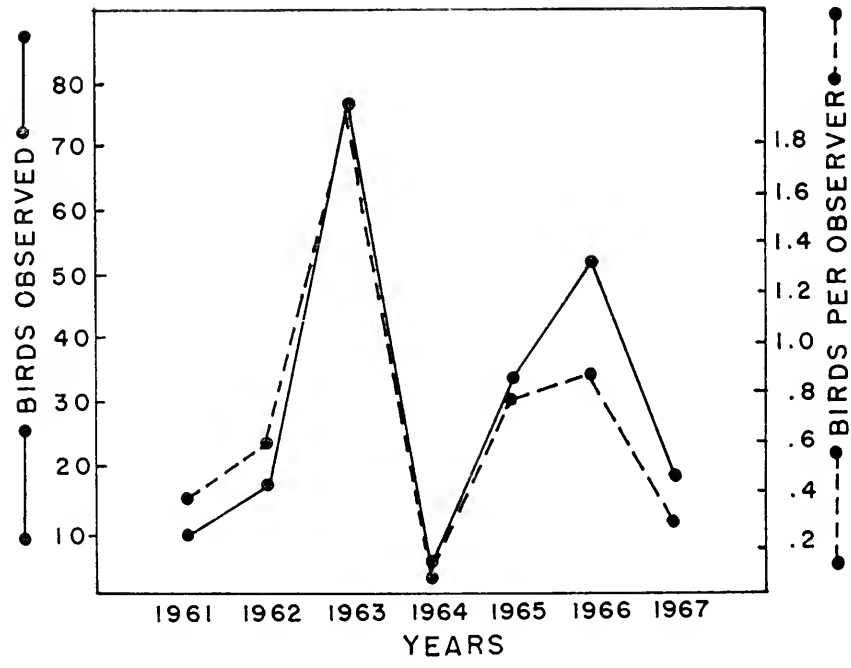

FIGURE 3. White-tailed kites as reported by Audubon Christmas counts.

RESULTS

Communal Night Roosting

The main Goleta Valley kite roost was discovered in October 1965 in a mixed live oak-willow grove on More Mesa, an extensive grassland area at the southeast corner of the study area. This roost was occupied until mid-November 1965, when the kites moved approximately ¾ mile northeast to a dense live oak stand. This second site was within 200 yards of a housing development and immediately adjacent to ranch buildings and pasture. The final move of the season occurred on December 23, 1966 to a relatively small clump of eucalyptus trees 330 yards southwest of the second location. The 1966–67, 1967–68 seasons followed a similar pattern of occasional changes in roost location.

Relative changes in numbers of the birds using the main roost showed similar patterns during the three years of the study. During the fall there was a gradual increase in birds utilizing the main roost to a peak population in early winter. In mid-January the birds using the main communal night roost began to dwindle because they remained in nesting territories at the onset of breeding season (Figure 4). We are confident that there was only one main roost utilized at a given time in the study area.

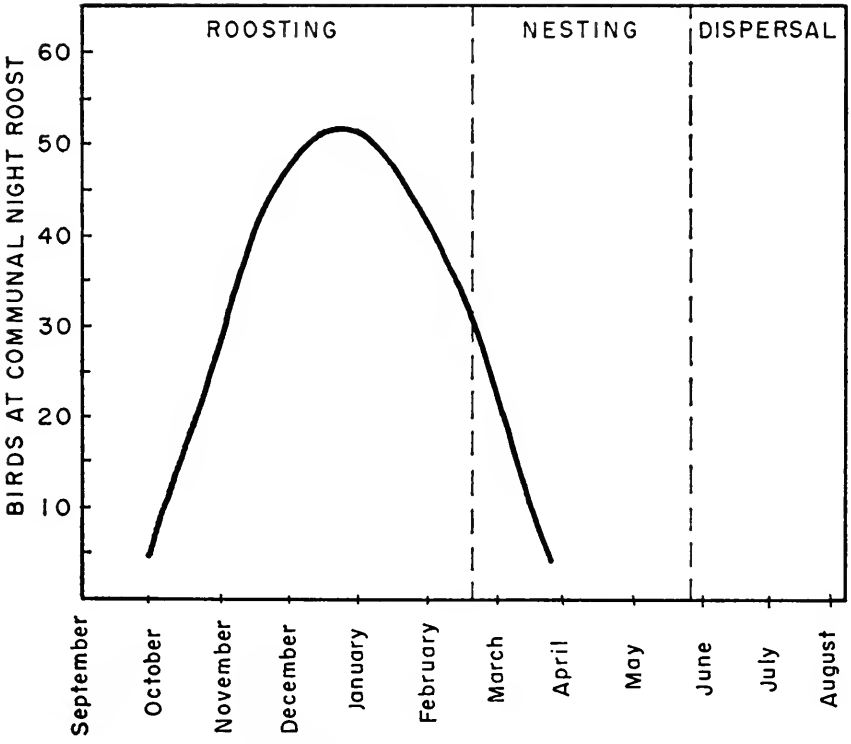

FIGURE 4. Kite use of communal roosts.

Concomitant with the initial buildup of birds using the roost in the fall, an increase in the number of pairs and individual birds occurred on territories throughout the valley. Occasionally individuals and pairs occupied a territory for a period ranging from a few weeks to several months, then moved to another location in the valley.

During the 3 years several patterns of behavior were evident at communal night roosts. Kites arrived during a 35 to 45-minute period generally between sunset and dark. Considerable aerial activity, such as hunting, was evident in the vicinity of the roost during arrival. At dark aerial activity diminished and within two or three minutes all the birds disappeared into the roost trees foliage. Observations of kites leaving a territory for the roost indicated that occasionally a pair left and flew in together, but more often they left individually, sometimes as much as 5 minutes apart.

The birds tended to leave in the morning as a group with slightly less illumination than was available to the last arrivals in the evening. During the day they spread out in the valley to various hunting and/or nesting territories. Rarely was a kite seen at the roost during the day.

During the first year (1965–66), several successful nests were started in the valley within one mile of the roost. The female remained at night at the nest site much earlier in the breeding cycle than the male. After incubation had progressed for some time or after the eggs hatched the male remained at the nest site during the night.

Food Habits

Kites restrict their hunting to open and moderately open areas, especially grasslands, marsh, or grassland with sparse brush. Hunting consists of intermittent soaring, flapping, and stationary hovering flights at heights generally less than 100 ft above the ground. Stationary hovering flight attitude is accomplished by slow wing beats with the bird usually heading into the prevailing wind. On making a stoop, the bird extends its wings in a steep "V" overhead, dangles its legs, and makes a slow vertical descent.

Hunting occurs at any hour between sunrise and sunset with the greatest activity in early morning and late afternoon. Most of the searching for prey is while the bird is in the stationary hovering position or in flight. The vertical drop is rarely made from the flapping or soaring attitude. Kites do not generally hunt from a perch as often as sparrow hawks (*Falco sparverius*).

The remains of 777 small mammals, representing three important prey species and two species of minor value, were in the 544 pellets examined, Table 2. Major prey species were the California meadow mouse, (*Microtus californicus*), the house mouse, (*Mus musculus*), and the harvest mouse (*Reithrodontomys megalotis*). Other small mammals were a shrew (*Sorex* sp.) and white-footed mice (*Peromyscus* sp.) which comprised less than one percent of the total animals. Four percent of the pellets contained fur only.

Mean measurements of pellets from different locations showed little variation. Average dimensions and ranges of 523 measured pellets were 32 (25-43) x 24 (14-39) x 18 (15-24)mm.

DISCUSSION

The first account of large kite aggregations was by Morgan (1948). He saw up to 25 perched kites at dawn at Camp Pendleton in San Diego County. Since 1948 several authors have seen large numbers of kites together at one time. Dixon (1957) saw a roost of birds in San Diego County. Bolander and Arnold (1965) observed up to 156 kites flying into a possible night roost. Most recently, Fry (1966) discovered a kite roost of approximately 100 birds near Sacramento.

Accounts in the literature, records of the California Department of Fish and Game Raptor Reporting Program, personal communications, and our observations suggest that communal night roosting by white-tailed kites occurs statewide at least during the non-nesting season. Generally main communal roosting occurs from mid-summer to late winter. Some communal roosting may occur during the nesting season; such activity may represent non-mated or otherwise non-nesting birds or males of incubating females.

The results of the food habits studies correspond to those of previous authors (Bond, 1940, 1942; Cunningham, 1955; Dixon, et al, 1957; and Hawbecker, 1940). The white-tailed kite is an important and almost obligate predator of diurnally active small mammals that inhabit open to moderately open areas of low vegetative cover. It is surprising that the highly nocturnal harvest mouse appeared in such high numbers in the current study, Table 2. Other possible prey animals such as *Peromyscus*, *Thomomys*, *Neotoma*, and *Citellus* may be too nocturnal or not within the appropriate size range to be taken in significant numbers by kites. These occur in the study area but with the exception of *Peromyscus* did not appear as a food item.

TABLE 2

Analysis of Contents of 544 White-tailed Kite Pellets Collected on the Goleta Valley Study Area

Species	Number of individuals	Percentage of total
Microtus	367	47
Mus	270	35
Reithrodontomys	137	18
Peromyscus	2	--
Sorex	1	--
Total	777	100

Many authors of general works listed a variable diet for the white-tailed kite, including insects, amphibians, reptiles, and birds (Bent, 1937). Such accounts gave the impression that the species is a highly adaptable predator capable of subsisting on a food supply of variable species composition. Observations suggested insects, amphibians, reptiles and birds were taken occasionally but they did not form a significant part of the kites' diet. Grassland dwelling small birds were listed in pellets analyses by Cunningham (1955) and Dixon et al (1957). Moore and Barr (1941) reported that insects in addition to mice were brought to the nest.

The possibility that certain prey species were eaten, but did not appear in the pellets cannot be overlooked. It has been shown that analyses of pellet contents from certain species of raptors are of limited value in assessing food habits of a species. Insect exoskeletons or bird bone fragments would be expected to appear in the pellets if such prey were eaten.

The California meadow mouse is the staple prey for the white-tailed kite in the Santa Barbara area and apparently throughout its range in California. The introduced house mouse provides a second important prey species, particularly where it has spread into fields in significant numbers. Populations of both of these species of small mammals undergo great changes in density. Meadow mice populations are cyclical (Krebs, 1966). In a period of from 3 to 4 years their numbers may fluctuate from one or less per acre to 300 or more per acre. In addition, two fields within close proximity could be asynchronous. House mice, on the other hand, are not cyclical, but undergo irruptions with populations occasionally reaching extremely high densities (Pearson, 1963). Such changes in densities of prey populations greatly influence the distribution and movements of a population of white-tailed kites and contributes to their rather nomadic behavior.

Several behavior patterns of the kite may be useful to exploit an asynchronous cyclical prey. The nomadic social behavior of the kites in the Goleta area could have adaptive significance for exploitation of localized seasonal or otherwise cyclical high mouse populations. Although nesting pairs in the Goleta Valley appeared widely spaced and vigorously defended territories, several past studies suggested that kites nest in close proximity with little hostility. Territorial flexibility correlated to prey density is well documented for several avian predators, especially those that subsist on cyclical small mammal prey (Pitelka, 1955).

Evidence from the literature, personal communications, and observation, suggested kites breed most of the year and successfully raise two successive sets of young.

One further aspect of their behavior suggests that they are ideally suited to exploit a localized high mouse population. Occasionally kites were seen to congregate and hunt in groups, often returning to the same field for several weeks. It is possible the attraction of the kites to specific fields for hunting may involve the same signals as those used to gather at the roost.

The small mammal populations of the Goleta Valley have not been studied in detail, but casual observations and limited trapping suggest that changes in abundance of meadow mice and house mice occur. The magnitude of the fluctuations or the degree of asynchrony is not known. An irruption of house mice occurred during the summer of 1963, but how widespread the outbreak was is not known.

At this writing, no specific conclusions can be drawn about the relationships between the white-tailed kite and its prey. However, widespread changes in abundance of prey population as well as localized asynchronous changes will undoubtedly influence the population stability of kites in the Santa Barbara region.

Obviously additional field work on kite behavior and ecology is needed. The group hunting phenomenon particularly needs further investigation such as trapping of small mammals to ascertain if there is a high mouse population in the field during periods of group hunting, and experimental manipulation of the mouse population to see if kites are attracted to an artificial mouse irruption.

A paramount objective in all further kite work should be a determination of population densities, distribution, and movements. This best could be accomplished through coordinated statewide annual counting and individual marking of birds with radiotelemetry the most promising system.

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In addition, we are grateful to Mr. Howard Leach, Special Wildlife Coordinator with the Department, for his help preparing the manuscript, and to Cliffa Corson for preparing the illustrations.

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CALIFORNIA CONDOR SURVEYS, 1969[1]

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The fifth annual California condor *(Gymnogyps californianus)* survey was conducted on October 15, 1969. The second day of the scheduled two-day survey was cancelled because of inclement weather conditions. Two hundred and twenty-eight sightings were reported by 27 of 51 manned stations. These sightings, by an evaluation of field reports, were reduced to a minimum count of 53 individual birds. Procedures for evaluating survey results remained the same as for all annual surveys.

An experimental baiting survey was conducted October 21–24, 1969 to further check its usefulness as an alternate to the annual condor survey. Ninety-two sightings were reported by five of the eight stations, but no birds fed on the bait.

INTRODUCTION

Cooperative surveys of the California condor population have been conducted annually in October since 1965 to determine trends in the condor population. The fifth Annual California Condor Survey, coordinated by the Condor Technical Committee, was conducted October 15, 1969. The third experimental baiting survey was conducted October 21–24, 1969.

METHODS

Annual survey methods and evaluation procedures were essentially the same as reported for the 1965–68 surveys (Mallette et al., 1966 and 1967; Sibley et al., 1968 and 1969). Changes in the 1969 survey included two additional stations in Kern County and the deletion of 17 stations from areas where condors were not reported during the last four surveys. The changes aided materially in evaluating the survey results.

Experimental baiting survey methods and evaluation procedures were essentially the same as reported by Sibley et al., (1969). Changes in the 1969 baiting survey included the addition of two bait stations, relocation of two and elimination of prebaiting.

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[2] Prepared for and with approval of the Condor Technical Committee: Chairman Robert Jones, former Chief of Wildlife Management Branch, California Department of Fish and Game; A. Starker Leopold, Professor of Zoology, University of California; A. E. Hall, Jr. U.S. Forest Service; Clinton H. Lostetter, U.S. Fish and Wildlife Service; John C. Borneman, National Audubon Society; W. Dean Carrier, U.S. Forest Service; and Robert D. Mallette, California Department of Fish and Game.

FIGURE 1. California condors at roost near observation station, October 15, 1969. *Photograph by Jahn C. Borneman.*

WEATHER

Weather on the first day of the scheduled two-day annual survey was generally fair and warm, turning to overcast skies during the day, winds 5 to 15 miles per hour from the north. The second day of the survey was cancelled because of inclement weather. Wet roads prevented observers from reaching many stations and several observation stations had zero visibility.

Weather was generally fair and partly overcast for the four-day baiting survey, with light winds of 5 to 10 miles per hour from the east.

RESULTS

Annual Survey

Fifty-one stations on October 15 were manned by 94 observers who reported 228 condor sightings from 27 stations (Figure 1). The evaluation of these sightings reduced the individual condor count to 53. The

age classification was 39 adults, 6 young and 8 unknown. Observers also reported 1,541 other raptors of 13 species (Table 1). On October 16, the survey was cancelled because of inclement weather.

TABLE 1

Raptor Sightings Reported During Annual Condor Survey October 15, 1969

Species	Number reported
Turkey vulture, *Cathartes aura*	1,158
Golden eagle, *Aquila chrysaetos*	90
Bald eagle, *Haliaeetus leucocephalus*	1
Sharp-shinned hawk, *Accipiter striatus*	23
Cooper's hawk, *A. cooperii*	19
Red-tailed hawk, *Buteo jamaicensis*	167
Swainson's hawk, *B. swainsoni*	4
Ferruginous hawk, *B. regalis*	2
Rough-legged hawk, *B. lagopus*	5
Sparrow hawk, *Falco sparverius*	41
Pigeon hawk, *F. columbarius*	1
Prairie falcon, *F. mexicanus*	4
Marsh hawk, *Circus cyaneus*	4
Miscellaneous raptors	22
Total	1,541

Annual survey results indicated a relatively stable condor population. Recruitment of young birds to the population remained low. Of the condors classified to age, only 13% were young birds. This is significantly below the 25 to 30% estimated by Koford (1953) as necessary to sustain the population.

Baiting Survey

The experimental baiting survey was conducted on October 21–24, 1969. Eight stations were manned by 16 observers, and 92 condor aerial sightings were reported from 5 stations during the four-day survey. No condors were seen feeding on the bait. The evaluation of these sightings produced individual condor counts of 6, 12, 6 and 4, respectively, for October 21–24 (Table 2).

TABLE 2

Results of Experimental Condor Baiting Survey October 21–24, 1969

Station	County	Individual condors seen*			
		Oct. 21	Oct. 22	Oct. 23	Oct. 24
1. Beartrap Canyon	San Luis Obispo	0	0	0	0
2. Pine Corral Potrero	Santa Barbara	0	0	0	0
3. Snedden Ranch	Kern	1 young	0	0	0
4. Tejon Ranch Grapevine Peak	Kern	1 adult	9 adults	4 adults	2 aduits
5. Tejon Ranch Winter's Ridge	Kern	3 unknown	2 juveniles	1 juvenile	2 unknown
6. Ellsworth Ranch	Kern	0	0	0	0
7. Bucksnort	Ventura	0	0	0	0
8. Hopper Mountain	Ventura	1 adult	1 adult	1 adult	0
Total		6	12	6	4

* No condors fed at the bait stations.

Results of the experimental baiting survey indicated that availability of natural or other food sources at this time of the year, influenced the effectiveness of bait in concentrating birds. Two reports during the four-day survey period supported this theory. Nineteen condors observed feeding on stillborn calves on the Tejon Ranch during the survey period were not sighted by observers at bait stations. Two birds were observed roosting in April Canyon, 1½ miles east of the Bucksnort bait station, Ventura County, but no birds were observed from this station during the survey.

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NOTES

PREDATION ON THE PURPLE URCHIN BY THE LEATHER STAR

Extensive grazing and destruction of giant kelp, *Macrocystis* spp., by two sea urchin species, *Strongylocentrotus franciscanus* (Agassiz) and *S. purpuratus* (Stimpson), has been discussed by North (1966). To date, few natural sea urchin predators living within the nearshore kelp stands off southern California have been identified.

On November 26, 1969, while diving in the kelp beds off Point Loma, California (lat 32°42'N, long 117°16'W), we observed the leather star, *Dermasterias imbricata* (Grube), feeding upon the purple urchin, *Strongylocentrotus purpuratus*, at a depth of 45 ft. On four subsequent dives within this kelp stand during January 1970, we examined 138 leather stars at depths between 35–75 ft. Sixty-eight of these sea stars were feeding and of these, 43 were consuming purple urchins (Figure 1).

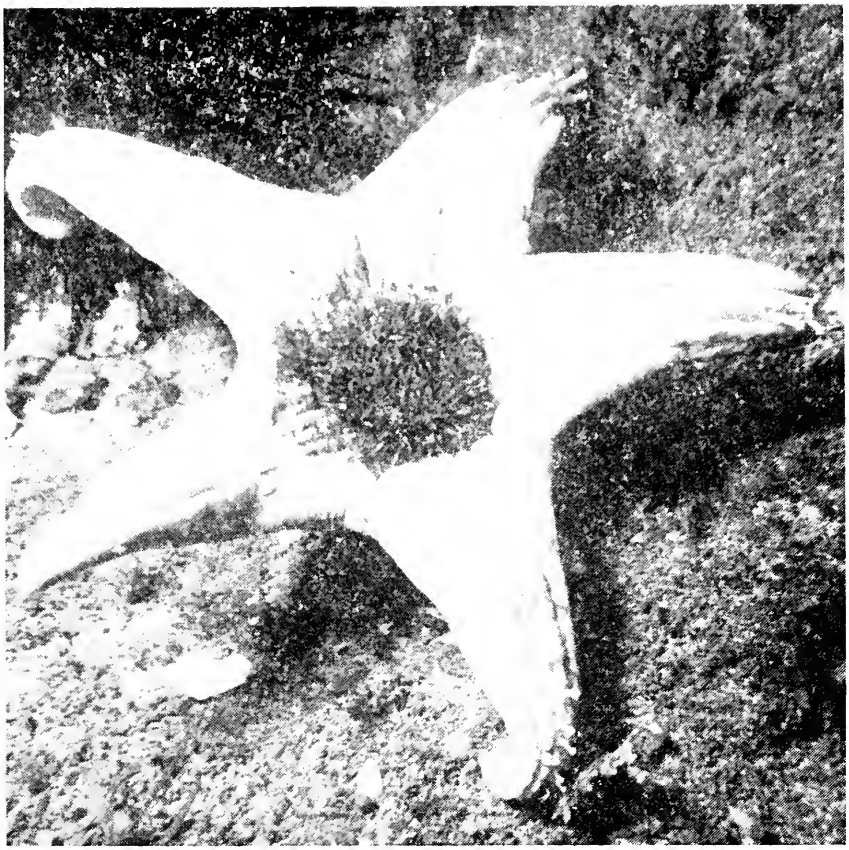

FIGURE 1. A leather star turned over to show it feeding on a purple urchin off Pt. Loma, California.

Predation by asteroids on purple urchins in subtidal areas of southern California had been unreported up to this time. Mauzey, Birkland, and Dayton (1968), working in the intertidal, observed that urchins form a major portion of the diet of the sea star, *Pycnopodia helianthoides* (Brandt), along the open coast of Washington.

Numbers of leather stars and purple urchins were placed in shallow experimental tanks at the U.S. Bureau of Commercial Fisheries Laboratory, La Jolla, California, to observe the behavioral interactions of these two organisms. Leather stars upon contact, elicited defensive as well as escape responses in purple urchins. The responses of the urchin included: localized spine movement, extension and opening of poisonous globiferous pedicellariae, and a backing or running away from the sea star. Jennings (1907) described similar reactions by the purple urchin when it encountered the sea star, *Astrometis sertulifera* (Xanthus), under laboratory conditions. The urchin can respond defensively seconds after contact by *D. imbricata* or *A. sertulifera*.

Additional observations should enable us to assess the impact which the leather star is having on the purple urchin population off Pt. Loma, California.

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—*Richard J. Rosenthal and James R. Chess, Westinghouse Ocean Research Laboratory, San Diego, California 92121.* *Accepted March 1970.*

WESTERN RANGE EXTENSION OF THE ROSETHORN ROCKFISH, *SEBASTES HELVOMACULATUS* (AYRES)

On April 19, 1967, one 310 mm (FL) female rosethorn rockfish was taken in a bottom trawl fished at 145–167 fathoms, east of Sitkinak Island (lat 56°22′N, long 152°21′W) in the Gulf of Alaska, by the Japanese stern trawler *Yutaka Maru*. Previous recorded range of the rosethorn rockfish was from Coronado Bank off San Diego (Lo-chai Chen, San Diego State College, pers. comm.) to 65 nautical miles east of Cape St. Elias (off Kayak Island), Gulf of Alaska (Westrheim, 1965). The capture off Sitkinak Island represents a southwestward range extension of about 365 nautical miles.

The Sitkinak Island specimen separates clearly from the rosy rockfish, *S. rosaceus* (Jordan and Gilbert), on the graph of orbital width against standard length given by Phillips (1957) and agrees closely with his description of *S. helvomaculatus*. My identification was veri-

fied by Lo-chai Chen. The specimen is deposited in the fish collection of the U.S. Bureau of Commercial Fisheries Biological Laboratory, Auke Bay, Alaska (collection number AB 67-63).

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—*Jiro Nishimoto, U.S. Bureau of Commercial Fisheries Biological Laboratory, Auke Bay, Alaska.* *Accepted March 1970.*

OBSERVATION OF MATING BEHAVIOR OF THE STRIPED PERCH AND NOTES ON POSSIBLE REPRODUCTIVE ACTIVITY OF THE RAINBOW PERCH

Mating activity of the shiner surfperch *Cymatogaster aggregata* Gibbons, was described by Hubbs (1917) and that of the pile perch, *Rhacochilus vacca* (Girard), by Limbaugh (1955). The following descriptions of the mating behavior in the striped perch, *Embiotoca lateralis* (Agassiz), and apparent breeding behavior in the rainbow perch *Hypsurus caryi* (Agassiz), bear many similarities to the accounts of these authors.

On October 9, 1969, while diving approximately 100 yards offshore at the southern boundary of Cannery Row, Monterey Bay, California, I observed two 12 to 15 inch striped perch in about 25 ft of water. They were situated approximately 5 ft above a sandy bottom with scattered small reef formations and were moving toward me. The most striking feature of each was the bright yellow snout. While one specimen assumed the normal vertical or slightly oblique swimming position, the other swam parallel to it in an almost horizontal plane. The anal fins were situated opposite one another, but I could not determine if contact was made. The pair remained in this close proximity for 2 to 3 seconds while the horizontal specimen appeared to shudder or vibrate. Either due to detection of my presence or as a normal interruption of the mating process, the vertical fish darted off and the other followed.

Prior to this observation and during the same dive, 20 to 30 embiotocids, tentatively identified as rainbow perch, were sighted in the same area. Each 8 to 10 inch specimen had an elongated ventral region and was marked by several vertical bars on a dusky silvery background, a black spot on the dorsal fin and a black "mustache". I first noticed the school of rainbow perch near the junction of a small reef and a metal pipe, milling about in a group which ranged throughout the lower half of the water column. The swarm passed over the reef, apparently ignoring my presence. Upon reaching a sandy area next to the pipe, a few fish left the group and "flashed" along the bottom, i.e., turned on their sides, thus reflecting light from their horizontal, silvery surfaces as they darted a few inches above the bottom for a

distance of about a foot. At this point, a large striped perch appeared from under the pipe and drove the school away. However, a few minutes later the swirling group of rainbow perch passed over the reef again. A third appearance incited another "attack" by the striped perch. Wherever a sandy substrate appeared between small rock formations a few specimens began to "flash" along the bottom. This behavior corresponded well with that observed among large groups of breeding shiner surfperch in the nearby Monterey marina in late July and early August of 1969.

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OBSERVED INTERACTION BETWEEN DESERT BIGHORN SHEEP, *OVIS CANADENSIS*, AND REPORTED PREDATOR SPECIES

The wildlife predator-prey relationship is an often discussed and little observed part of the natural environment. The following observations are offered concerning the relationship of predators to desert bighorn sheep. These observations are only single occurrences and should not be taken as typical behavior of the species involved.

On June 18, 1969, Jerry Mensch and Ron Thomas observed an interaction between an adult female bighorn and an adult golden eagle *(Aquila chrysaetos)* in Carrizo Canyon, San Diego County, California. During this observation the eagle circled over the bighorn at an estimated height of 150 ft while the bighorn repeatedly lowered its head and moved it from side to side. This behavior continued for approximately two minutes until the bighorn moved below the crest of a ridge. The eagle continued soaring over the general area at a higher elevation and after approximately two minutes was out of sight. The sheep appeared to be alone and showed little interest in the eagle after moving below the crest of the ridge.

A second observation of interaction was made on July 10, 1969, in the Providence Mountains of San Bernardino County, California, by Jerry Mensch, Ron Thomas, and Richard Weaver. They observed what appeared to be a nonantagonistic meeting of an adult male bighorn and an adult bobcat *(Lynx rufus)*. The bighorn was feeding on a steep slope and showed interest in an area slightly uphill and to the rear. The ram continued feeding until confronted by a large bobcat that had jumped on a large flat rock near the level and alongside of the ram. The two animals approached each other and each appeared to smell the nose of the other animal from a distance of less than 6 inches. After a few seconds the ram stepped back, shook his head slightly, turned and resumed feeding. The bobcat then jumped off the rock and disappeared

between some boulders. The bighorn indicated no further interest in the area where the cat disappeared.

On September 28, 1969, Richard Weaver watched three feral burros (*Equus asinus*) and a bighorn ewe at Wood Mountain Spring in eastern San Bernardino County. The burros were standing in the spring and the ewe was approximately 25 ft above the burros. She appeared to wait for the burros to leave so that she might come to the water. At 7:30 a.m. a coyote (*Canis latrans*) approached the spring on a contour along the hillside following a well-defined burro trail. When it was within 50 ft of the ewe and level with her she lowered her head and charged the coyote at a hard run for over 200 ft where the coyote disappeared from sight. The ewe returned to her stand above the spring but the coyote did not reappear. When the observer was seen by the ewe she left the spring and took another stand closer to the observer, watching him continually. While the ewe was at this location another coyote approached the spring from a different direction. The coyote passed between the observer and the ewe walking to the spring on a contour 50 ft below the sheep. It was obvious that she saw the coyote but had no reaction to it.—*Richard A. Weaver and Jerry L. Mensch, Wildlife Management Branch, California Department of Fish and Game. A Contribution of Federal Aid to Wildlife Restoration Project W-54-R, "Big Game Investigations." Accepted March 1970.*

WATERFOWL BOTULISM IN CALIFORNIA—1969

California experienced a heavy waterfowl mortality due to botulism in 1969. Losses exceeded 140,000 waterfowl and shorebirds, Table 1. Many more birds would have died if it were not for the massive control effort of the U.S. Bureau of Sport Fisheries and Wildlife and the California Department of Fish and Game.

An interagency meeting was held in Hanford in mid-April to define and identify the forthcoming botulism potential and to coordinate the activities of the Bureau, Department, U.S. Army Corps of Engineers and sportsmen groups. The Hanford planning meeting was specifically for the San Joaquin Valley, many areas of which were being flooded by record high precipitation. About 130,000 acres of land was under water.

In May a second meeting was held in Sacramento to plan control activities in the remainder of the State.

Botulism in the San Joaquin Valley appeared during late May with continued sporadic individual outbreaks until November. The typical pattern of an outbreak was as follows: (i) losses would be detected by aerial surveillance; (ii) ground crews would be dispatched to pick up the dead and sick waterfowl and set up bird frightening devices to keep the healthy birds away from toxic areas.

There were no significant losses in the Sacramento Valley until late September when botulism was noted on six marsh areas. How long the outbreaks had existed prior to detection is unknown, but when noticed there were many sick, dead, decomposed ducks on two of the areas. Four of the areas involved had only small scale outbreaks and were easily controlled, the remaining two areas were major outbreaks and

could not be quickly brought under control because of the heavy vegetative cover. Losses on the Sacramento Valley areas continued through the hunting season but at a greatly reduced rate.

The situation at Tule Lake and the Lower Klamath was normal with regard to biological factors and birds lost.

Surveillance and application of control procedures were the keys to limiting statewide mortalities to 140,000 birds. Losses in the Tulare Lake area alone have exceeded 250,000 in the past. The cost of the management, control and research programs for State and Federal agencies was $321,000. Table 1.—*Brian F. Hunter, Wildlife Management Branch, California Department of Fish and Game. Federal Aid in Wildlife Restoration Project W-52-R, "Wildlife Investigations Laboratory." Accepted March, 1970.*

TABLE 1

Number of Birds Involved and State and Federal Costs by Area

	San Joaquin Valley	Sacramento Valley	Tule Lake and Lower Klamath	Total
Dead birds picked up	41,526	54,618	8,046	104,190
Estimated total dead	45,174	84,124	10,750	140,048
Sick birds successfully treated	7,816	3,388	2,496	13,700
State cost	$115,088	$21,803	$5,060	$141,951
Federal cost	127,550	40,957	10,700	179,207
Total cost	$242,638	$62,760	$15,760	$321,158

LARGE BLACK BEAR FROM YOSEMITE

Occasionally it is necessary to eliminate certain black bears (*Euarctos americanus*) from heavy public use areas in national parks. These animals are usually persistent "nuisance" bears, responsible for numerous property damage complaints or visitor injuries in public campgrounds. One such black bear was collected near Camp Curry in Yosemite Valley, Yosemite National Park, California, on September 28, 1966. It weighed 690 pounds on a truck platform scale. This bear was a male, of medium brown coloration. It had a prominent hump at the shoulders, resembling closely a grizzly when silhouetted by the headlights of a vehicle.

Only the skull, including the lower mandible was salvaged from the carcass. On December 9, 1969, the prepared skull was taken to the California Academy of Sciences, in San Francisco, for measurements by their Department of Birds and Mammals. The skull measurements by calipers were as follows: greatest overall length, 349.25 mm (13 1/16 inches); width across zygomatic arches, 222.25 mm (8 3/16 inches). These measurements exceeded all black bear skull dimensions listed by Boone and Crockett Club (1964). The above skull was made a part of the Academy's permanent collection; catalog number CAS 15274.

REFERENCE

Boone and Crockett Club. 1964 Records of North American big game. Holt, Rinehart and Winston, New York. 398 p.

Neal G. Guse, Jr., Office of National Sciences Studies, National Park Service, Grand Canyon, Arizona. *Accepted March 1970.*

OCCURRENCE OF A FLAMINGO AT TOMALES BAY

On November 27, 1966, James R. Stone and four companions observed a flamingo (*Phoenicopterus ruber*) approximately ½ mile northeast of Hog Island, Tomales Bay, Marin County, California. Tomales Bay is on the Pacific Coast about 40 miles northwest of San Francisco. The Bay extends 10 miles southwest from its entrance and in most places is less than a mile wide. The swimming bird was observed for about 20 minutes from a distance of approximately 150 yards and examined closely through 6 x 30 mm binoculars. At the time, approximately 10:00 a.m., the weather was clear with a moderate wind blowing from the southeast. The bird flew when approached by boat and appeared to land in the area just south of Tom Point, approximately one mile north of Hog Island.

A Kodak Instamatic Super 8 camera with a zoom lens was used to document the observation. Colored 8 mm motion pictures were taken of the flamingo as it swam near the observers and also as it flew away. These motion pictures were viewed several times by the author. The landscape of Tomales Bay and the general shape, color and other identifying features of the flamingo shown in the film established the authenticity of this sighting.

On November 29, 1966, Mr. Stone observed a flamingo standing on the mudflats at the mouth of Walker Creek, where it enters Tomales Bay. The bird was observed with 6 x 30 mm binoculars for about 10 minutes, from a distance of approximately 400 yards. The weather was clear.

The author, Mr. Stone and others have collectively spent considerable time observing wildlife on Tomales Bay from 1959 to the present. We are not aware of any other instances of actual or reported sightings of flamingos during this period. Nick Kojich, now deceased, spent most of his life on the Bay. The flamingo seen on November 27, 1966, was the first he could remember seeing or hearing about in over 50 years.

The observations reported herein probably were of the same flamingo. Since captive flocks are often maintained in the San Francisco area it is likely that this bird was an escapee. Rechnitzer (1959) reported the occurrence of a flamingo in the wild in Southern California. Harris and Yocom (1965) reported a flamingo that was seen along Smith River, Del Norte County, California, during Christmas week, 1964, and one sighted approximately 100 miles south of there near Cape Mendocino, Humboldt County, California, in February 1965. Tomales Bay is about 200 miles south of Cape Mendocino. The present observations are of interest in that they add further documentation to this birds' ability to survive in the wild, for short periods at least, under the

varying local climatic and habitat conditions found in South
Northern, and now the coast of Central California.

REFERENCES

Harris, Stanley W., and Charles F. Yocom. 1965. Sight record of a flamingo
Humboldt County, California. Murrelet, 46 (2) : 28–29.
Rechnitzer, Andreas B. 1959. Flamingo in a Southern California slough. Con
61 (2) : 156.

—*Richard J. Wheeler, Science Department, Petaluma Second
Schools, Petaluma, California 94952.* *Accepted February 1970.*

BOOK REVIEWS

Handbook of Freshwater Fishery Biology, Volume One

By Kenneth D. Carlander; Iowa State University Press, Ames, Iowa, 1969; 752 p., illustrated. $15.

Fishery biologists are fortunate that Professor Kenneth Carlander had the initiative and ability to produce his widely known and used *Handbook of Freshwater Fishery Biology* in 1950, a second edition and supplement in 1953, and since then the time and perseverance to compile the first volume of their successor. He expects that at least two years will be required to complete the manuscript for the second volume.

Volume One contains life history data on freshwater fishes of the United States and Canada, exclusive of the Perciformes. It represents a comprehensive revision of the 1953 publications and includes data on several phases of the life histories of the fishes not previously covered.

Following the preface and a rather detailed introduction, the present volume devotes 560 pages to life histories of species, succeeded by a group of conversion tables, then citations, and finally author and subject indexes. The 1950 edition included data from 1,122 citations, the 1953 supplement brought the list to 1,593, while the citations in the current volume and those already examined for the second volume number more than 4,400. Data have been drawn from mimeographed or otherwise duplicated reports, theses, and typed reports as well as published works.

Certainly all libraries, as well as many individuals, should have this comprehensive index to the literature on their shelves.—*Leo Shapovalov.*

Checklist of Canadian Freshwater Fishes With Keys for Identification

By W. B. Scott and E. J. Crossman; Life Science Misc. Publ., Royal Ontario Museum, 100 Queen's Park, Ontario, Canada, 1969; 104 p. $1.50 paper.

Electronics for Biologists

By Franklin F. Offner; McGraw-Hill Book Company, New York, 1967; xi + 185 p., illustrated. $6.95.

This book is intended to familiarize the biologist with the fundamentals of electronics so that he might better select, operate, and modify electronic equipment to be used in data gathering. In the first three chapters the author reviews basic electronics and explains various components such as condensers, vacuum tubes, diodes, transistors, and capacitors. Various oscillographs are covered next, with descriptions of each kind and their relative merits. Chapter 5 deals with electrophysiological electronic practice. The remaining chapters cover such topics as semiconductors, transistor circuits, feedback, amplifier types and designs, power supplies, transducers, electrodes, and stimulators. The author writes in a clear and concise manner and does not expect the reader to have a prior knowledge of electronics. I recommend this book to anyone who plans to acquire data by use of telemetry or an electrophysiological approach.—*Paul A. Gregory.*

Advances in Ecological Research, Volume 6

Edited by J. B. Cragg; Academic Press, London and New York, 1969; xi + 236 p., illustrated. $10.

This sixth book in an annual series contains four articles. The first, "The Dynamics of Aquatic Ecosystems", by K. H. Mann, is a review of production in aquatic environments. The author reviews both primary and secondary production, studies of both whole ecosystems and single species, and decomposition. The treatment is thorough and well written but brief, the article being just 71 pages long. A major part of its value is an extensive bibliography.

There are a few places where I feel clarity could have been improved. For example, in the section on secondary production, the use of a bar to denote a mean is not consistent. Also in this section, I think the distinction between the methods of Jensen and Allen for estimating production would be clearer if they were illustrated with the same figure, emphasizing that they differ only in the axis chosen to

integrate over. These failings are minor though, and the article is well worth reading.

The second article, "Integration, Identity and Stability in the Plant Association", by Arthur N. Langford and Murray F. Buell, has little that is pertinent to ecology in aquatic environments. It is a consideration of community structure in terrestrial plants. Much of it is an historical review of the development of differing concepts of plant associations. I felt that this development would have been more useful if greater emphasis had been placed on describing the concepts, with less emphasis on the rights, wrongs, and omissions in various papers written during the past 50 years.

I also found the article generally difficult to follow meaningfully, because I am not familiar with the jargon used in this specialization. For example, a major section entitled, "Neutral Approaches to Community and Association Study", starts by stating that two pairs of terms, "ordination and classification" and "integrated community and individualistic community" have each been "set in mutual opposition for years". The section then proceeds to discuss this at some length without offering any definition or description of the concepts.

The third article, "Ecological Conditions Affecting the Production of Wild Herbivorous Mammals on Grasslands", by A. deVos, is based largely on studies of North American and African grasslands. This article is interesting, well written, and easily understood. The author discusses subjects in quite general terms, usually not including quantitative supporting facts, and sometimes not citing supporting references. In several places, the author aroused but failed to satisfy my curiosity. For example, he points out that, depending on local conditions, burning may either increase or decrease humus, but he fails to point out any principles controlling which of these opposite effects will result.

The fourth article, "A Simulation Model of Animal Movement Patterns", by D. B. Siniff and C. R. Jessen, describes progress toward development of a simulation model to describe animal movements within their home range. Basically, the authors have made substantial progress toward developing a computer model capable of simulating movement patterns observed in wild mammals through telemetry. Besides producing information about this specialized subject, the article illustrates the difficulties involved in simulating even a small part of an ecological system.—*H. K. Chadwick.*

Environmental Conservation, Second Edition

By Raymond F. Dasmann; John Wiley and Sons, Inc., New York, 1968; xiii + 375 p., illustrated. $8.95.

This excellent book is described in the introduction as "an attempt to look at our environment and human problems from the viewpoint of conservation". This it does very well.

It is no reflection on Dasmann that, nine years following his first edition, he still must cover essentially the same ground in his new edition. The problems read dismayingly the same, and there is still the imperative call to action: ". . . nobody can escape some share of responsibility; nobody can avoid the world in which he lives. Failure to act can only result in the need to live with the consequences of other people's actions".

The new edition has some 69 more pages, and there is a shift in emphasis throughout the book to problems of overpopulation, recreation, urban environments, and preservation of species and natural environments.

The "Agriculture and Soil" chapter is essentially the same—clear, excellent pictures and description; however, this new edition adds the sections "World Food Problems" and "The Pesticide Problem", which are short, concise summaries of two extremely critical problems—really far too short.

I note that a 1959 edition chapter read "Forests and Man"; the new reads "Timber and Man", but little else has changed. It is not clear why the picture on page 272 is repeated on page 277.

The discussion beginning on page 280, concerning "Steps Toward Preservation", is good as far as it goes. But, in the opinion of this reviewer, the issue of the basic conflict between a policy calling for complete protection and preservation of nature and a policy making nature available for public enjoyment deserves far more attention. Also, the report to the National Park Service, by the committee headed by A. Starker Leopold, with respect to the management of wildlife and wildlife habitat within parks, might have been more fully treated. Further, "wilder-

ness preservation" and "small natural areas" are extremely important subjects and really are not considered in the detail which they deserve.

The "Rare and Endangered Species" section omits a discussion of the problems which may arise when a rare species does make a comeback and other species or uses of species are adversely affected. In this connection one might point to the current controversy along the central California coast with respect to the sea otter and the abalone fishery.

Dasmann is generally low key in his examples, and one feels that more could be said about freeways in parks and urban open-space problems than is said on pages 294–296.

Pollution is touched on but lightly: less than four pages on pesticides *per se* and less than one page on solid wastes. This appears to be an inadequate treatment in comparison with the magnitude of the problem.

The problems of overpopulation are well-documented and discussed, but the practical steps to solve these problems are missing. In fact, if I am left with any sense at all of disappointment with this book it is one of incompleteness.

It is not clear why the subject of nuclear energy is treated under "The Urban Environment", and why it is treated solely as a problem. Actually, the use of nuclear energy for power may result in a significant improvement in atmospheric quality, and in fact may be the only feasible way by which large amounts of electricity can be generated. Certain statements on nuclear energy are misleading; for example, the author's statement that *high levels* of radio-activity have been disposed of through the use of concrete-lined barrels sunk in the ocean has not been the case. *Low level* wastes were formerly placed in concrete-lined barrels and disposed of at sea, but no sea burial of nuclear wastes has been made in California, for example, since 1962. The low level radioactive wastes formerly disposed of at sea are now buried underground in remote land areas, such as near Beatty, Nevada. High level wastes are also stored in various underground containers on land, and have not been disposed of at sea in this country.

Dasmann makes excellent points under his topic, "Politics and Conservation". He correctly emphasizes the need of planners to work with local planning agencies, and the further need to get the support of local organizations to accomplish conservation action.

This is a good book and the references are invaluable and well chosen. If I were to have available only one text from which to teach conservation principles, I would probably choose this one.

Every specialist, whether he be lawyer, economist, wildlife biologist, social worker, engineer—or whatever—should read this book. It will help anyone to see how inextricably one's own profession and actions are bound up with the environment in which he lives—and hopefully to see that the only way that things will get done is through efforts beginning at the level of the individual.—*Harold D. Bissell.*

The Life in the Desert

By Ann and Myron Sutton; McGraw-Hill Book Company, New York, 1968; 232 p., profusely illustrated. $4.95.

The lives of plants and animals found in the desert and how they have adapted and survived is unfolded in this picturesque book.

Major deserts of the world are briefly described—from the Gobi to the large barren areas of the Arctic. The main subject is a basic introduction to the North American deserts. Two trips are available to the reader: one, of 24 hours duration, shows the great changes which occur between night and day, while a second trip covers the dramatic seasonal changes of the desert.

The absence of scientific names and the brief treatment given to endangered species, particularly the cyprinodonts, is disappointing. However, *The Life in the Desert* provides enjoyable and informative reading, particularly for those planning a trip to the desert.—*James A. St. Amant.*

Wildlife Management Techniques (Third Edition: Revised)

Edited by Robert H. Giles, Jr.; The Wildlife Society, 3900 Wisconsin Ave., N.W., Washington, D.C., 20016, 1969; viii + 623 p., illustrated. $10 (plus $1 for overseas postage).

Here is a book about which this reviewer could offer a plethora of praise and plaudits. This enthusiasm about the qualities may be engendered in part by the "research" format. The general chapters begin with the plan of the project then logically proceed to the library in the chapter on the use of the literature by librarian Robert W. Burns, followed by the collection and maintenance of reprints. Unfor-

tunately the next two chapters are not in correct sequence—"Writing the Scientific Report" precedes "Making Observations and Records". All of the succeeding chapters cover the field of wildlife techniques in great detail.

Perhaps some feeling for the book may be passed on by a quotation from the introductory chapter by editor Giles, the instrument responsible for the genesis of this incomparable edition. ". . . this book . . . does present the techniques of wildlife management chapter by chapter in an order appropriate to the fulfillment of the scientific method. The book itself becomes the demonstration of an acceptable approach to wildlife management. The chapters and their authors have been selected so that the reader, when he has experienced the book as a whole, will not only have an understanding of the scientific process but also might have caught a glimpse of the meaning of wildlife management as an art, and can begin becoming an artist, as well as a scientist."

Not incidentally, the illustrations by Larry Toschik are truly works of an artist. When pondering over a statistical presentation or some other section which requires mental labor there is a refreshing pause while the reader returns the gaze of a fawn or watches the jump and flight of mallards vividly portrayed by the art of Toschik.

Henry S. Mosby did heroic work in producing the first and second editions, and he laid the groundwork for Giles' third edition. However, while the Model A was an improvement over the Model T, this production is analogous to the appearance of the Lincoln Continental. The book is printed on glossy paper with a two column format. Many of the photographs in the previous editions have been incorporated in the third, but they are clearer and some authors have revised their illustrative material.

In this day of a deluge of scientific reports the chapter on wildlife literature clearly and concisely offers the reader a means of keeping abreast with developments in his specialty, especially through the use of the index/abstracting services.

Thomas G. Scott and James S. Ayers have a brief but meaty chapter on writing the scientific report, including the editorial life history of the manuscript. They should have indicated the variation between journal formats particularly in methods of citing the literature.

Chapter seven is titled "Instrumentation", but it is concerned with power sources, audial and visual instruments, activity recording devices and weights and measures. The following four chapters all deal with instruments. Lowell Adams on Computers has simplified this ultimate extension of wildlife management to the technological age. To use or not to use he answers by a simple equation of "time—cost".

M. T. Myres has expanded the former seven lines on Radar to four pages with four illustrations. The discussion not only includes the use of radar to study migration, but how this tool may be useful in the manipulation of nuisance species, particularly at air terminals.

The radioisotope discussion by Tony Peterle is more detailed than in the previous edition, however he omitted the summarization of advantages and disadvantages of the techniques which was valuable in the previous edition.

Chapter 13 has an apology by the editor for lack of revision of the topic "Habitat analysis and evaluation". However, the next chapter by Jim Yoakum and William Dasmann on habitat manipulation is new. Intensive habitat procedures are thoroughly covered including techniques to improve food, water and cover for the mammals and marsh management with water control methods for water birds. The reviewer pondered the reason why there were only 12 lines on controlled burning as contrasted to two pages on mechanical methods of brush management. The authors provided an excellent summary which other authors could have done to improve their chapters.

Food habits has been completely rewritten by the same author, Leroy Korschgen. He added sections on nutrition and bioenergetics as well as the application of food habits data for forensic purposes.

The post-mortem examination techniques by I. McTaggart Cowan was revised by Lars Karstad. The grouse dissection photograph in the previous edition has been replaced with a much clearer mallard dissection picture. Greater stress should have been placed on the importance of submitting the entire animal to a competent comparative pathologist. The following chapter by Mosby, Cowan and Karstad includes sections on handling materials for virological, bacteriological, parasitological examination, etc. as well as other methods of collecting materials. It may have been better to have the rules for collecting disease and parasite specimens included in the post-mortem examination chapter.

Fred Zwickel wrote a new chapter on the use of dogs in wildlife management. He included many situations where dogs are not only helpful but actually surpass man in accomplishing certain desired objectives, e.g. censusing and herding. However, the chapter is somewhat repetitious and a better coverage of handling and training without adding to the length of the section could have been done. A few paragraphs on equipment and the care and feeding of dogs would have been helpful.

Richard Taber's chapter on the criteria of sex and age is much the same with the inclusion of just two additional plates. He repeated the section on the bursa of Fabricius verbatim, "The function of this organ is not precisely known . . ." despite many papers published during the last 6 years which describe experimental work on this organ known to be responsible for the immune mechanism in birds. In the second edition the excised cloaca of game birds was illustrated with letter designations of the parts. The third edition labelled all of the parts but the legend repeated the letter designations which now refer to nothing. One of the tables carries over the number assigned to it in the earlier edition.

Chapter 21 was updated and it is obvious that the limiting factor on the addition of recent data was press time. This chapter on estimating numbers was by previous author David E. Davis, but co-authored by statistician W. Scott Overton. Some of the ideas are easy to follow, however others are given which will defy the most astute wildlife workers. Dasmann's buck-doe ratio with the hunter kill as a modified Kelker ratio was simple to follow in the second edition but in this issue it is impossible to determine without reference to the earlier edition. The chapter becomes more difficult as the reader progresses since statisticians assume their readers are adept at following their multitudinous mathematical manipulations. On the other hand the next chapter on population analysis by new author L. Eberhardt is new in approach and organization with some simplification of what could be an extraordinarily complex subject.

Chapter 23 on nuisance wildlife is expanded and contains a new section on the identification of predators by carcass examination. The end of the chapter gives a useful list of supply houses for all the devices described in the text. The notable exception is the BSF&W Pocatello Supply Center.

Editor Giles wrote the last chapter on population manipulation. There is an excellent outline of the factors which influence populations and their application to management. Giles' final words express the improvements in this edition, ". . . wildlife management will advance as a science for the benefit of man and the wildlife resource."

Although this book must become an integral and valuable part of the wildlife management curriculum, it also must be used by the professional in the field to bring his knowledge to a current level, and as a constant reference source.—*Merton N. Rosen*

The Life of the Cave

By Charles E. Mohr and Thomas L. Poulson; McGraw-Hill Book Co., New York, 1967; 232 p., illustrated. $4.95.

The Life of the Cave takes a look at the largely unexplored caverns under the earth's surface. Animals that are able to survive in this relatively barren environment are examined, and their evolution and specialization for survival in a world of darkness is vividly described. Since food is the main limiting factor in caves, the food chain is restricted to a few species. All of the basic food utilized in the cave comes from sources outside the cave.

Both troglobites, the cave dwellers, and troglophiles, animals that can complete their life cycle either in caves or in suitable outside habitats, are covered. The authors describe 29 species of animals, including four species of fish. Unfortunately, pupfish, of which there are several endangered species, are not mentioned, since the authors limit their coverage mainly to major cave areas in the midwestern United States.

Only a short presentation is given on the topic that is becoming a major public concern, man's deleterious effect on his environment. Since the book deals extensively with cave ecology it is unfortunate that more emphasis was not given to how we can save what is left of these very unique communities. In spite of these shortcomings, spelunkers, as well as those who have never heard of spelunking will find *The Life of the Cave* educational and enjoyable reading.—*James A. St. Amant*

Handbook of Rocky Mountain Plants

By Ruth Ashton Nelson; Dale Stuart King, Tucson, Arizona, 1969, 331 p., illustrated. Cloth $6.95, paper, $4.95.

This is another of the increasingly numerous and popular "handbook" approaches to natural history. It is not intended to be definitive, but rather includes 972 of the more common and "conspicuous" plants found in the Rocky Mountains, with emphasis on the plants of the national parks and monuments.

There is a section on the Rocky Mountain environment for background, giving brief accounting of climate, soil, landscape, and vegetative zones. The bulk of the text is confined to species accounts, which have been thoughtfully and beautifully digested for popular consumption. Sprinkled through this latter section are 362 excellent black and white line drawings of representative plants, which some ambitious users of this handbook may enjoy filling in with color. There are 12 color plates located in the center of the book illustrating 72 plant species.

The keys (to four large groups, family, genera) seem workable for anyone who will purchase a small hand lens and tackle the few botanical terms in the glossary. A section, including good schematic diagrams of plant characteristics, will make this job easier and infinitely more pleasant.

Anyone taking a summer trip through the Rockies will enjoy having this book along with their birdbook. Take the paperback. The quality of the paper in the clothbound makes the later a trifle overpriced.—*Bruce Browning*

Big Game Hunting Around the World

By Bert Klineburger and Vernon W. Hurst; Exposition Press, New York, 1969; 376 p., illustrated with 52 p. of full-color and black-and-white photographs. $15.

The majority of the writing in this book is by the authors. However, there are other contributors; Vidya Shukla of India; Gary Joll, New Zealand; Dr. Frank Hibben of the University of New Mexico; and Chris Klineburger, the author's brother.

The initial chapters are devoted to the psychology of the hunter, selection of clothing and equipment and a brief account of skinning and care of trophies. From here the book goes into various accounts of big game hunting throughout the world. Hunting in Alaska and Canada is well covered but our own hunting in the continental 48 states received light treatment, as did Mexico.

The illustrations range from poor to excellent. Many are taken on the spot and it is realized that sometimes conditions are not always propitious for taking professional type pictures. Big game hunting is a great and worthy sport. However, I offer a comment on the subject of illustration. Care should be taken to present the trophy in as lifelike a pose as possible and blood spattered subjects should be avoided. The psychological factors that may adversely affect public opinion should be taken into account in presenting the sport of hunting.

The book is generally well presented in a popular style; however, there is an unfortunate typo where the captions to figures 46 and 47 have been reversed.

The book is excellent in its presentation of hunting and hunting conditions around the world. The accounts of actual hunts are all entertaining. Anyone interested in the subject of big game hunting will enjoy reading this book. I'm sure many hunters will be amazed at the quality and variety of hunting still available in the modern world.

Modern transportation can take you to at least the near vicinity of excellent game areas in a hurry and in comfort. Now to get that trophy all you need is the urge and some time and money.—*C. M. Ferrel*

Freezing and Irradiation of Fish

Rudolf Kreuzer, Editor; Food and Agriculture Organization of the United Nations, Rome, and Fishing News (Books) Limited, London, 1969; 528 p., illustrated. £11 10s. 0d.

This is the record of the FAO Congress held in Madrid, September 1967, on the Freezing and Irradiation of Fish. Eighty papers from world experts establish this book as the current authority on the freezing of fish for human consumption.

The papers are grouped into six categories and these are subdivided by subject matter:

1. Freezing Fish at Sea
   a. Techniques and Equipment for Freezing Fish at Sea
   b. Factors Affecting Quality of Sea Frozen Fish

c. Freezing Media
d. Superchilling
2. Freezing and Processing Frozen Fish
a. Physical Effects of Freezing Fish
b. Specific Problems and Techniques in Freezing Fish
c. The Effect of Polyphosphate Treatment
d. Freezing of Tropical Fish
e. Thawing Frozen Fish
3. Economics of Producing and Marketing Frozen Fish Products
a. The Future of the Shore-Based Freezing Industry
b. Economic Factors Affecting the Fish Freezing Industry
c. Economic Consideration in the Developing Fish Freezing Industries
d. Product Development
4. The Quality of Frozen Fish Products and its Assessment
a. Factors Influencing Quality of Frozen Fish Products
b. Quality Assessment
5. Storage, Packaging and Distribution of Frozen Fish Products
a. Design and Operation of Cold Stores
b. Packaging and Distribution of Frozen Fish Products
6. Preservation of Fishery Products by Irradiation
a. The Quality Aspects of Seafood Irradiation
b. Present Status and Considerations Regarding Wholesomeness
c. Economic Aspects and Production Technology

Those who are concerned with processing, preserving and distributing 10% of the world's animal protein for human food (160 to 200 million tons of fish annually) must have the information presented by 161 specialists at the Madrid meeting, now made available in this volume.—*Robert R. Bell*

The Encyclopedia of Marine Resources

Edited by Frank E. Firth; Van Nostrand Reinhold Company, New York, 1969; xi + 740 p., illustrated. $25.

The needs resulting from an expanding world population with its increasing utilization of land resources are causing many people to look toward ocean resources as a means of maintaining the present economic growth of the world. The purpose of this book as stated by Mr. Firth, "is to help serve these needs by presenting the most significant aspects of the ocean's resources, together with summaries of a few closely related topics considered necessary to round out the treatment."

As editor, Mr. Firth has enlisted the knowledge and experience of more than 150 authorities from many countries, including several biologists with the California Department of Fish and Game. These persons have contributed more than 125 articles to this volume.

Most of the articles are concerned with marine fisheries, fishing methods, and gear. Other subjects covered vary from marine ecology to heat and power from the sea. Articles also are included about new technical advances, such as satellite sensing, which may become valuable aids to fishery technicians and marine biologists. Most of the ocean fisheries are covered by region rather than on a species basis. A few of the more important ocean fisheries and some more obscure fisheries which would not appear in a regional coverage were handled on a species basis. A considerable amount of fairly current fisheries statistics is included with the articles. Most of the articles, however, are little more than summaries and anyone needing indepth coverage of a subject will have to go to another source.

This is not a book that most people would read from cover to cover, nor was it intended as such. There are articles that will provide enlightening and enjoyable reading for the interested layman as well as for those working in the various fields of marine resources. Those who take the time to browse through it, reading articles that meet their fancy, should gain a good perspective of current worldwide developments in ocean resources; and this, after all, is the purpose of the book.—*John Geibel.*

Refrigeration on Fishing Vessels

By J. H. Merritt; Fishing News (Books) Ltd., London, 1969; 148 p., illustrated. £2 12s. 6d.

The world population's demand for fresh ocean fish products is growing at an ever-increasing rate. This demand cannot be met by fishing vessels operating at the

doorstep of every ultimate consumer. Thus, it becomes necessary to preserve this perishable commodity for varying lengths of time. Since decomposition of fish tissue begins at the time of death, it is necessary to initiate techniques to retard the growth of decay organisms as soon as possible. Salting and drying have been used to impede decay; however, refrigeration (the process of making cold) has become the most widely accepted method of preserving fish for market.

One will find in this small volume a thorough discussion of this timely subject, with a minimum of technical terminology. The author is a trained engineer who has specialized in preserving fish. His subject is discussed thoroughly from the reasons for the process through various methods of icing and freezing and culminating in the latest methods of brine-spray refrigeration. Throughout, the text is generously illustrated with diagrammatic sketches.

Exclusive use of the metric system for expressing measurements may prove burdensome to the American reader. However, this may be overcome with patient use of the equivalents glossary which has been provided.

Fishermen, refrigeration engineers, technicians or anyone else interested in the preservation of fishery products should find this book an invaluable reference.—*William L. Craig.*

Finding Birds in Mexico (Second Edition)

By Ernest Preston Edwards; Ernest P. Edwards, Sweet Briar, Va., 1968; xxii + 282 p., illustrated in color and black-and-white. $6.95 cloth, $4.95 paper.

This second edition of a popular book by Ernest Edwards has been enlarged to provide a reader greater insight into where to go and what to look for on a birding trip to Mexico. Informatively, the writer has divided Mexico into regions and subregions based on physiography and then grouped the common birds according to habitats. This is followed with a discussion of 68 Mexican localities and an illustrated guide to birds of Mexico.

One who desires to travel to Mexico to sightsee will do well to purchase this book, not only to plan his vacation, but to serve as a guide once Mexico is reached. For example, if one plans a trip to Guaymas he will be provided a description of the city, its climate and industry and most importantly specifically where to go nearby to find birds of the Northern Pacific Lowland subregion.

There may be some critics who feel the bird listings are incomplete, but few can quarrel with the value of "Finding Birds in Mexico" in providing a handy and useful guide book.—*Howard R. Leach.*

The Seine Net: Its Origin, Evolution and Use

By D. B. Thomson; Fishing News (Books) Ltd., London, 1969; xviii + 192 p., illustrated. £4 5s 0d.

This book is a comprehensive work on the historical development, design, and use of the seine net. Although this form of commercial fishing is not in use on the west coast of the United States, it can best be compared to the more familiar otter trawl both in its function and species taken.

The seine net does not have boards or beams to keep the net open, and is basically a long bag with two long narrow wings to which are attached floats and weights. The net fishes as it is drawn toward the boat by a winch. Seine nets are mainly used for the capture of high quality demersal fishes fairly close to shore.

The book is written for the British Isles audience and is a little difficult to comprehend if one is not familiar with the English monetary system or the use of stones as a standard measurement of weight.

Diagrams of various net designs and descriptions of the different fishing methods are excellent. They will be of great help if one is interested in using this type of net.

The author certainly knows his subject and on the whole the book is well written.—*Eric H. Knaggs.*

Wild Sanctuaries: Our National Wildlife Refuges—A Heritage Restored

By Robert Murphy; E. P. Dutton & Co., Inc., New York, 1968; 288 p., illustrated. $22.50.

From various areas of our country, including Alaska and Hawaii, Robert Murphy has chosen some fascinating National Wildlife Refuges to visit and write about. Moosehorn in Maine, Cape Romain in South Carolina, Aransas in Texas, Cabeza Prieta in Arizona, Malheur and the Klamath Basin Refuges in Oregon, Irenai, Kodiak, and Nunivak in Alaska, and the Hawaiian Islands National Wildlife Refuge

are only a few of the refuges visited. Most of them were chosen because they are typical of the region of our country in which they are found. Some, such as Okefinokee in Georgia, were chosen because the country itself or the creatures it contains are unusual or endangered.

Typical areas covered in the discussion of each refuge is its history before and after being established, why it was established, the kind of country in which it is found, and its flora and fauna. The kind of public recreation allowed at each refuge is also mentioned. A map preceeds each discussion. Numerous black and white and full color photos graphically illustrate the typical country and the major wildlife found at each refuge. The quality of these photographs is excellent.

In addition, the author has included an appendix which lists 170 additional wildlife refuges, with a paragraph about each, that are not covered in the main text. A very comprehensive index is also included.

The text is non-technical and the authors style helps make this book very enjoyable reading. It should be of interest to the hiker, camper, fisherman, hunter, or anyone who appreciates unspoiled America. It's the kind of a book that one enjoys browsing through again and again just to look at the photographs or to read about a particular refuge that would be interesting to visit. This book should help to build appreciation for our wildlife and its preservation. Unfortunately the price is bound to limit its sale.—*Ernest W. Lesh, Jr.*

Principles of Systematic Zoology

By Ernest Mayr; McGraw-Hill Book Co., New York, 1969; xi + 428 p., illustrated. $12.50

It seems superfluous to review *Principles of Systematic Zoology*, when one considers that a single sentence on the dust jacket pretty well sums up the situation by saying that this book "is a completely updated, expanded, and rewritten guide and companion for those who are learning systematic zoology and those who are teaching it." The only fault I find with this statement is that it fails to mention its potential value as a deskside reference for the practicing systematist—the individual who is neither a student nor a teacher.

After an introductory preface and a 19-page chapter entitled "The science of taxonomy," the volume is divided into three sections. Four chapters explain the principles of zoological classification, and are followed by six chapters on methods of zoological classification. The final section, probably the most useful to the professional or working scientist deals with the principles and application of zoological nomenclature. One of two chapters in this section spells out the rules of zoological nomenclature, and its companion chapter offers an interpretation of these rules.

A bibliography, glossary, and index complete the volume.

In my opinion, *Principles of Systematic Zoology* is one of the best basic investments that a student, teacher, or professional can make, if he intends to pursue or continue a career in the field of zoology. However, to reward the purchaser, the book must be used; it should never be allowed to sit on a shelf and gather dust.—*John E. Fitch.*

The Pacific Salmon Fisheries, A Study of Irrational Conservation

By James A. Crutchfield and Guilio Pontecorvo; Johns Hopkins Press, Baltimore, Md., 1969; 220 p. $6.

For years Dr. James Crutchfield has been trying to convince the fishing industry and the administrators of fishery management agencies that present conservation efforts are foredoomed to failure, as long as additional boats are allowed to enter a fishery and catch the fish that have just been "saved" by stringent conservation methods. Crutchfield also has maintain that the economics of the fishing industry could be greatly improved, and that some real conservation could result if the number of fishermen in a particular fishery were kept low enough so that it would not be necessary to reduce their efficiency (and increase their costs) in order to prevent overfishing. Such a reduction in fleet size could be done by various forms of attrition and without hardship for individual fishermen, and would permit the average hard-working, full-time fisherman to make more than a starvation wage.

In "The Pacific Salmon Fisheries", Crutchfield and Pontecorvo have concentrated on the salmon fisheries of Alaska and Puget Sound, but cite many examples from other areas. The authors barely touch on the troll fishery or the sport fishery.

Conservation methods, economics, and biology are analyzed in enough detail so that a careful reader should be convinced of the validity of the basic claims stated above (plus a few more). Unfortunately, as the authors point out on p. 200,

". . . there are no simple remedies, though our analysis—like that of Scott, Gordon, Christy, Sinclair, and Turvey—indicates that the principles at issue are not complex. As in the case of North American agriculture, the key problems in achieving better economic performance lie in 'how' rather than 'why' or 'what.'"

The book is technical; non-economists and non-biologists will find it slow (but not impossible) reading in places.—*D. H. Fry, Jr.*

Antarctic Ascidiacea

By Patricia Kott; American Geophysical Union, Washington, D.C., 1969; xv + 239 p., illustrated. $16.50.

This 13 volume of the Antarctic Research series is the first monographic work, complete in one volume, about a widespread major group of antarctic marine organisms. The data reported upon typify the work which must precede any detail discussion of the flora and fauna of a particular region—the authoritative identification and distribution of each species present.

The volume is divided into three major sections. The first contains a classification for ascidians; the terms used in their description (with appropriate diagrammatic illustrations); and keys to the orders, suborders, families, and subfamilies of Ascidiacea. The keys will be useful to nonspecialists working with ascidians from areas other than Antarctica.

A systematic discussion of each of the 126 known antarctic ascidians encompasses the text's major pagination. Complete synonymy, collection records, distribution, and general life history information are given for the 122 specifically determined forms. For species discussed, there is a concluding remarks section which covers taxonomic and other considerations. The entire systematic discussion section is liberally illustrated with line drawings depicting colonies, zooids, larvae, internal anatomy, and taxonomically saliant structures of 108 species.

The concluding section deals with ascidian behavior (e.g., feeding, migration, orientation), phylogeny, and zoogeographic and faunal considerations. This is followed by a comprehensive reference list which will be most helpful to any biologist interested in this group of animals. In all but six instances, the author has checked each reference against its original publication.

Throughout the volume, one is impressed with the high degree of professionalism exhibited in the presentation of this material.

I hope that with this basic work completed, Dr. Kott or others will expand further the knowledge of biological parameters concerning these animals. It is unfortunate, however, that money and personnel seem so available to conduct and report upon detailed studies of marine environments in faroff places (e.g., Antarctica or the Indian Ocean) but are frequently unobtainable to study nearby areas and the problems brought to them by the tons of waste products resulting from an exploding population. An increase in concerted multi-discipline study of local marine regions also is sorely needed.—*Charles H. Turner.*

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